Grubel & Hudson

Tests of Band-Hooped Concrete Columns

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TESTS OF BAND-HOOPED CONCRETE COLUMNS

BY

EDWARD ALEXANDER GRUBEL
HARRY HENRY HUDSON

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

EDWARD ALEXANDER GRUBEL
HARRY HENRY HUDSON

ENTITLED TESTS OF BAND-HOOPED CONCRETE COLUMNS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Civil Engineering

A. N. Talbot
D. A. Abrams
Instructor in Charge.

APPROVED: Ira O. Baker

HEAD OF DEPARTMENT OF Civil Engineering

INTRODUCTION.

Concrete construction has had a remarkable development in the last decade and is now regarded by engineers and architects generally as a safe form of construction with a wide field of economic application.

Common practice established itself at first and all concrete work was given an extravagant factor of safety but in the last few years since reinforced concrete has attained popularity the outstanding uncertainties have been under investigation and rapid strides have been made toward establishing "good practice" in concrete construction.

Concrete is characterized by low tensile stress, relatively high compressive strength, and great durability. Its great advantages are its rust proof and fire proof qualities, its cheapness, its availability in almost any locality and the ease with which it can be molded into any desirable form.

For structural members carrying purely tensile stresses, steel must be employed as a reinforcement to the concrete and also for compressive stresses as in the case of long slender columns where there is lateral bending, but for large and compact members carrying compressive stresses alone, plain

concrete is used.

A number of tests have been made upon small test pieces such as cubes and cylinders but the data thus obtained did not allow a comparison to be made between the strengths of the cubes and cylinders and the corresponding columns since the strength of the small test pieces was usually greater than that of the columns.

Two series of column tests have been made at the University of Illinois. The first series was made in 1906 and reported in the thesis of R. C. Llewllyn '06 and in Bulletin No. 10 of the University of Illinois Engineering Experiment Station. These tests were made on plain and on two kinds of longitudinal rod reinforced columns. All columns were made square in cross section and were of two sizes, 12 in. x 12 in and 9 in x 9 in. The lengths were 6 ft., 9 ft., and 12 ft. All columns were tested in the 600000 lb. capacity Riehle vertical testing machine. The second series made in 1907 was reported in the thesis of Messrs. Mowder, Hoff and Grear and in Bulletin No. 20 of the University of Illinois Engineering Experiment Station.

These tests were made in the same machine and the specimens were plain, spiral and hoop-reinforced, all circular in cross section, a few being 9 in. in diameter and the remainder 12 in. in diameter.

The third series of tests just completed will form the subject matter of this thesis. This thesis however will report only the tests made on the columns having band hoop reinforce-

ment. The columns having spiral reinforcement are reported by Messrs. Gonnerman, Slaymaker and Weber, while Messrs. Burch and Hearey report on the pl~~ia~~ain columns tested. The band-hooped columns were of three different mixtures, 1-1-2, 1-2-4, and 1-3-6, and had three different sizes of reinforcement, 5/16 in. hoops, No. 12 hoops (about 0.106 in) and No. 20 hoops (about 0.036 in.) in thickness. Columns with the different mixtures and different reinforcement were tested at 14 days and 60 days. A comparison will be made between the strength of the columns of different mixtures, reinforcement and age. The relation between the load and the longitudinal deformation will be determined by means of curves and an effort made to determine Poisson's ratio for band hooped concrete columns.

The work of this thesis was divided between Messrs. Burroughs, Grubel and Hudson, the three working together on the different parts of the work, including the copying of observed data, computations, plotting of curves and the conclusion. The introduction and discription of materials was written by Hudson and the description of the apparatus and method of testing by Grubel. The actual testing of the columns included in this thesis was done by the writers and the men previously mentioned as working on this series of tests. Responsibility for the accurateness of the data rests with the party as a whole and no one man can be held individually as no one occupied the same position on all the tests.

II.

THEORY OF HOOPED CONCRETE.

Although it has been known for some time that restraint in a lateral direction adds to the strength of concrete in compression, the first extensive experiments along this line were made by Armand Considere. He investigated and utilized this method, now known as hooped concrete, in 1902. The columns used were supported laterally by means of spirals and bands. Most of the experimense were performed on small test pieces. The results of these tests are given in a work by Considere calles Experimental Research on Reinforced Concrete.

In 1907, a paper published by Considere discussed various experiments on hooped concrete. In this he gives the results of his experiments and his revised conclusion on this subject and also the results of the work performed by Bach. In this later work is given Considere's column formula which is applicable to short hooped columns.

$$C = 1.5\ c + 2400 + 5100\ p'$$

where C = unit strength of the hooped column.

C = " " " " plain " .

P = percentage of longitudinal reinforcement.

p^1 = percentage of hoop.

This formula expresses the unit strength of the reinforced column as the sum of

(1) Unit strength of plain concrete column increased 50%

(2) Strength of the longitudinal reinforcement stressed to

its elastic limit.

(3) Strength equal to that of 2.1 times the hooping reinforcement considered as longitudinal reinforcement and stressed to its elastic limit.

Hooping the concrete allows according to Considere the use of a leaner mixture and a smaller cross section for the same strength and stiffness. This method of reinforcement is of particular advantage in piles, struts and the compression parts of bridges. A series of tests made in 1906 by James E. Howard at Watertown Arsenal on columns reinforced with bands, spirals, longitudinal bars and angles show an increase of from 600 to 1000 lbs. per sq. in. in the strength of a column for a spiral reinforcement of 1% based on the area within the hooping. Most of the tests here mentioned were made on specimens having longitudinal reinforcement while the tests made at the Experiment Station at the University of Illinois in 1908 were mostly on columns having no longitudinal reinforcement.

III.

MATERIALS.

The materials used in the tests do not differ from those used in ordinary practice, the sand, stone, cement and steel all being purchased in the open market.

STONE:- The stone was a Number 1 crushed limestone from

Kankakee, Illinois, ordered to pass over a 1/4 inch screen and through a 1-inch screen. The percent of voids given below is the average of three tests.

TABLE 1.

Weight of Stone.

Loose Stone Lbs. per cu. ft.	Stone with voids filled with water Lbs. per cu. ft.	Water Lbs. per cu ft.	Percent Voids
85.1	116.6	31.5	50.4

The amount of voids in the stone was obtained by pouring the stone slowly into water so as to entirely fill the voids.

TABLE 2.

Fineness Tests of Stone.

Sieve Number	1	3/4	1/2	3/8	3	5	10
Percent Passing	100	89.2	54.7	32.8	16.9	4.1	2.5

These values are the averages of several tests and show the stone to be well graded and very little passing through a sieve less than 1/4 m.

TABLE 5.

Fineness Tests of Cement.

Cement	Percent Passing Sieve Number				
	50	75	100	150	200
Universal Portland	100	99.3	98.5		90.1
Chicago AA "	100	98.5	95.6		81.5

TABLE 6.

Tensile Strength of Cement.

Cement	7 Days		28 Days	
	Neat	1 - 3	Neat	1 - 3
Chicago A A	666	182	792	284
	811	227	833	307
	665	175	799	266
	732	192	857	318
	559	145	707	247
Average	687	184	798	284
Universal	699	242	754	292
	728	232	776	285
	809	248	885	336
	563	244	764	319
Average	700	242	795	308

TABLE 7..

STEEL TESTS.

Weld not in Tested Section.

5/16 in. Bands.

Size	Percent	Load		Load lbs. sq. in.	
	Elongation	Yield	Ulti-	Yield	Ulti-
in. x in.	in 8 ins.	point	mate.	point	mate
1.026 x .321	28	13370	19000	40700	57800
1.021 x .353	29	15600	23200	44200	65800
.998 x .314	28	13400	18700	42800	59800
1.007 x .324	28	13500	17800	38600	55000
.994 x .317	29	12300	17900	39100	56800
1.008 x .326	28	13700	19200	41600	58500
.996 x .319	32	12000	17100	37800	59300
1.002 x .318	29	13600	19100	42600	60000
1.000 x .381	27	15800	23400	41500	61500
1.014 x .316	31	13700	18800	42800	58800
.996 x .317	25	13600	18900	43100	59900
1.000 x .317	27	13600	19200	43000	60600
.996 x .317	26	14500	20100	46000	63700
.994 x .315	28	13400	18900	42800	60400
			Mean ------	41900	61100
		No. 12 Hoops.			
1.006 x .107	23	4700	6400	43700	59500
1.021 x .111	24	4900	6800	43400	60200
.994 x .102	22	5100	7200	50500	71300
.986 x .106	24	4700	6400	44800	61000
1.021 x .107	22	5200	6900	47700	63300
1.012 x .107	22	5200	6900	48400	63800
.996 x .108	23	5200	6700	48200	62000
1.016 x .109	23	5300	7100	47800	64000
.998 x .107	24	5200	6800	48600	63500
1.013 x .106	23	5000	6600	46700	61700
			Mean--------	46960	63030

TABLE 7.

STEEL TESTS.

Continued.

No. 20 Hoops.

Size in. x in.	Percent Elongation in 8 ins.	Load Yield point	 Ulti-mate	Load lbs. sq. in. Yield point	 Ulti-mate
.991 x .036	8	1900	2100	52800	58400
.982 x .036	20	1900	2300	55000	66500
.985 x .036	18	1700	2100	49400	61100
.990 x .036	23	1900	2400	52800	66700
.990 x .035	21	1800	2200	51400	62800
.986 x .035	22	1800	2200	51400	62800
.977 x .036	23	1800	2200	51500	62900
.974 x .036	25	1800	2200	51500	62900
1.014 x .042	14	2100	2600	48900	60500
.999 x .037	22	2000	2500	54100	67500
			Mean-------	51780	63210

Welds in Tested Section.

1 in. x 5/16 in. Bands.

1.050 x .315	17	16200	19900	50000	61400
1.012 x .318	13	16000	19800	49700	61600
1.005 x .314	14	16000	18900	51000	60300
1.031 x .312	17	15700	19800	48800	61500
1.028 x .315	13	16300	20100	50500	62300
			Mean-------	50000	61160

All specimens failed with good fracture, but near top jaw.
Yield point indistinct.

- o -

1 in. x No. 20 Bands.

1.022 x .032	0	1000	1000		30300
.987 x .035	1	1800	1800		51400
1.029 x .035	0	1500	1500		41700
.970 x .035	0	1700	1700		48600
1.014 x .033	0	900	900		27300
				Mean----	39860

All specimens failed at weld.

TABLE 7.

Continued.

1 in. x No. 12 Bands.

Size in. x in.	Percent Elongation in 8 ins.	Load Yield point	Load Ultimate	Load lbs sq in. Yield point	Load lbs sq in. Ultimate
*1.012 x .108	5	6000	6000		55000
1.001 x .106	22	6600	7400		69800
*1.008 x .108	5	5400	5400		50000
*1.009 x .120	11	5200	7000		58800
1.007 x .104	19	4200	6000		57700
*1.020 x .116	0	3200	3200		26300
*1.008 x .112	0	2700	2700		24100
*1.009 x .108	0	4500	4500		41700
* .995 x .107	0	3500	3500		32800
*1.004 x .111	2	5700	5700		51300
				Mean------	46850

*Ruptured at Weld.

CONCRETE:- Two men skilled in mixing concrete were employed and great care was used so that the test specimens would be made of a concrete as good as that found in the best structures. The materials were proportioned by loose volume and as a check all materials were weighed.

The concrete was mixed on a flat steel plate, used for a mixing board. The cement and sand was first put on this and thoroughly mixed by turning with shovels. Next, the stone wgich had been thoroughly wet was added and this mass was turned several times until it was uniformly mixed. The water was added and the mass turned until it had a uniform appearance. Usually three turnings would give this. The mixture used was

quite wet as this permitted the tamping into the forms to better advantage. One batch consisted of enough concrete to make one column together with the smaller test pieces, 12-in. cubes, 6-in cubes and cylinder.

Test Specimens:- All the specimens were made in a manner as nearly uniform as possible and the conditions of manufacture were practically the same. The stone and sand used were the same in all cases and the data concerning these may be found in Tables 1 to 4 inclusive. The cement was either Chicago A A portland or Universal portland, results of tests of which are recorded in Tables 5 and 6.

The steel reinforcement was of band hoops. The material was a medium open hearth steel. Results of tensile tests on the bands of different thickness are given in Tables 7 - 9 inclusive.

Band-Hooped Columns:- Columns were made and 25 were tested and the data resulting from these tests form the subject matter of this thesis. The columns were cylindrical in shape 12-in. in diameter inside the reinforcement. All the columns were practically 10 feet long and were either 14 or 60 days old at time of tests.

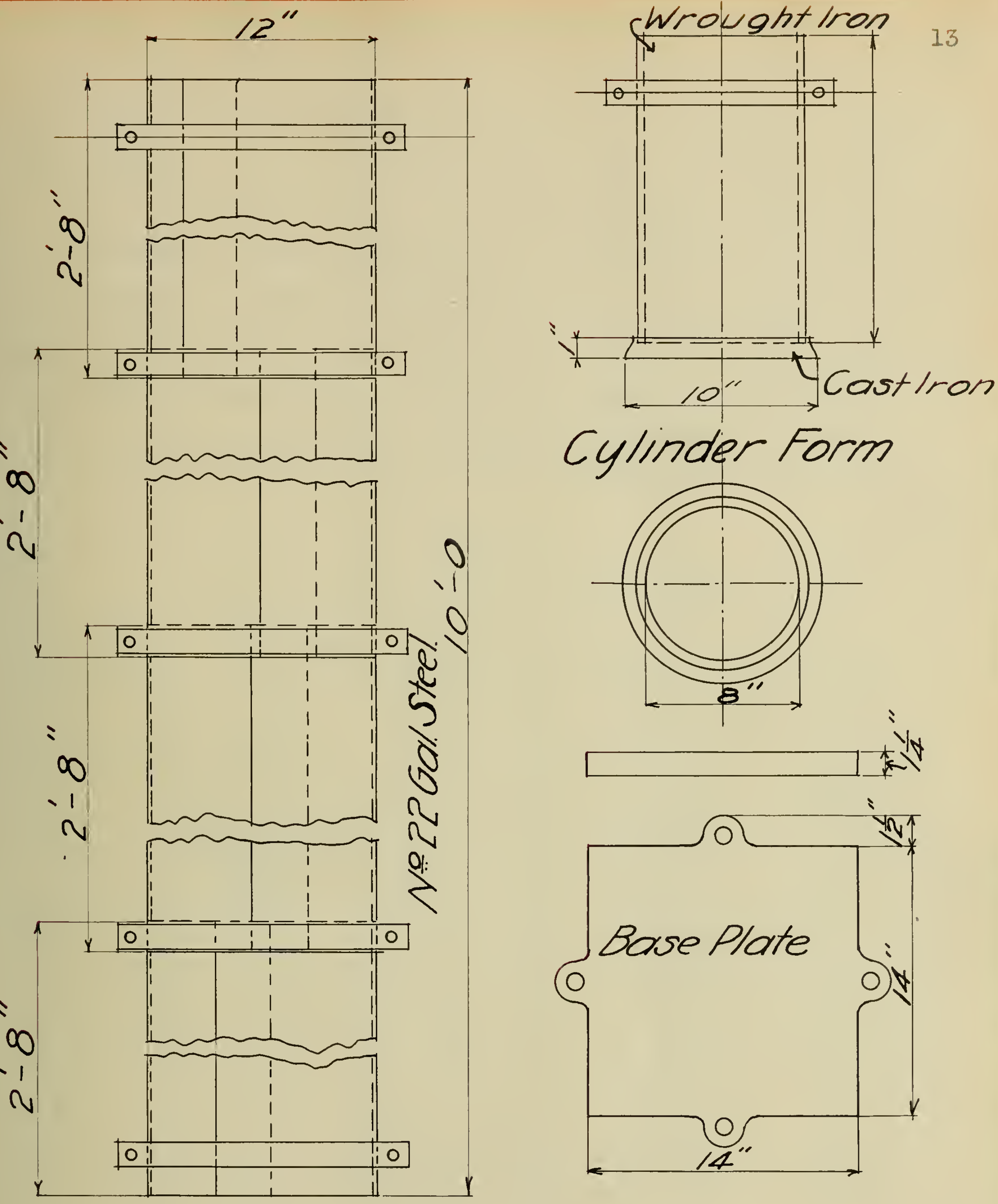
Auxiliary Test Pieces:- To give a check of the quality of the concrete in the columns, 12-in. cubes, 6-in. cubes and an 8-in. by 16-in. cylinder were made in nearly all cases from the same batch of concrete. In making the test pieces the

concrete was well tamped and troweled about the edges to give a good surface.

Forms for Columns:- The column forms were of galvanized sheet steel bent into the form of a cylinder and held in position by bands 1-in. wide and 3/16-in.thick. The bands could be adjusted to the proper diameter by means of bolts. These forms were in sections 2 1/2 feet wide and fitted together in stove pipe fashion.

Making of Columns:- The steel reinforcement of bands, measuring 12 in. inside diameter and held together by longitudinal strips, was encased in the steel forms and stood in a vertical position on an iron plate 14-in. by 14-in. by $1\frac{1}{4}$ in. This plate was planed on bŏth sides and served as a bearing plate in the test. The concrete was poured in from the top and tamped in layers about 6-in. thick until water flushed to the surface. This was continued until the column was the required length, approximately 10 feet.

Storage of Columns:- The columns were built near the walls of the Laboratory of Applied Mechanics and remained in a vertical position until tested. The forms were taken off the column 7 days after it was made and from the time the forms were removed until the column was tested, they were sprinkled with water daily. The temperature of the room ranged from 55° to 65°F. The 12-in. cubes were stored in open air in this same room and the 6-in. cubes and the cylinders were stored in



Form for Cylindrical Column
Fig. 1.

damp sand.

Summary of Test Pieces:- The following table gives the the results of tests on the specimens in the following order- 12-in. cube tests, 6-in. cube tests, 8-in. by 16-in. cylinder tests, and column tests. The corresponding numbers in each table are specimens made from the same batch of concrete.

TABLE 8.

Tests of Auxiliary Concrete Specimens.

Concrete same as in Col. No.	Mixture by Vol.	Mixture by Weight	12-in cubes		6 in cubes		8x16 in. cylinders.	
			Age in days	Ult. Str. Lbs. Sq In.	Age in days	Ult. Str. Lbs. Sq. In.	Age in days	Ult. Str. Lbs. Sq. In.
8121	1-1-2	1-1.340-2.23	63	4300	60	4585	64	4520
8122	1-1-2	1-1.240-2.11	70	3995	68	3910	74	2960
8111	1-1-2	1-1.32--2.24	60	4150	60	4220	60	4120
8112	1-1-2	1-1.28 -2.23	63	4355	59	4762	59	3970
8131	1-1-2	1-1.37 -2.18	20	3460	14	3657	14	2920
8179	1-2-4	1-2.61 -4.41	14	1048	16	1240	16	661
8161	1-2-4	1-2.53 -4.48	17	1445	15	1380	15	837
8171	1-2-4	1-2.62 -4.55	12	2059	13	1694	13	1590
8183	1-2-4	1-2.51 -4.12	56	2990	58	2228	59	1280
8184	1-2-4	1-2.55 -4.38	69	2905	69	2337	72	2220
8175	1-2-4	1-2.66 -4.26	63	2505	61	2988	61	1778
8176	1-2-4	1-2.47 -4.05	63	2685	49	2661	49	2565
8252	1-2-4	1-2.45 -4.01	--	-----	65	1863	69	1340
8173	1-2-4	1-2.46 -4.24	58	2250	59	2150	59	1508
8174	1-2-4	1-2.49 -4.29	64	3210	64	3283	65	2140
8163	1-2-4	1-2.65 -4.25	54	2680	57	3052	57	1780
8164	1-2-4	1-2.48 -4.22	74	3730	--	-----	--	-----
8231	1-3-6	1-3.69 -5.82	65	1650	61	1716	61	1245
8232	1-3-6	1-3.57 -5.96	68	1695	60	1523	64	920
8221	1-3-6	1-4.04 -6.45	59	1660	60	1578	--	-----
8222	1-3-6	1-3.73 -6.45	62	985	62	973	66	410
8223	1-3-6	1-3.09 -5.08	62	1762	60	1523	--	988
8211	1-3-6	1-3.57 -8.23	63	1930	60	2104	--	-----
8212	1-3-6	1-3.58 -6.23	63	2350	59	2221	59	1468

Note:- The values given for 12-in. cubes are the average

of the test on two cubes and those for 6-in. cubes the average of the test on three cubes. But one cylinder was made and tested for each column. The values of the different tests did not vary much from the average.

TESTING MACHINE USED.

All the columns and the 12-in. cubes were tested in the 600000 lb. capacity Riehle vertical screw machine of the Laboratory of Applied Mechanics. This machine is capable of testing specimens up to 25 feet in length in tension or compression. In the tests the lowest machine speed, 1/20 inch per minute, was used except on column No. 8181 where the speed was increased to 1/10 inch per minute and later increased to 4/10 inch per minute. The photographs show the column in the machine in the position for testing. The 6-in. cubes and the cylinders were tested in the Olsen machine of 100000 lb. or 200000 lb. capacity.

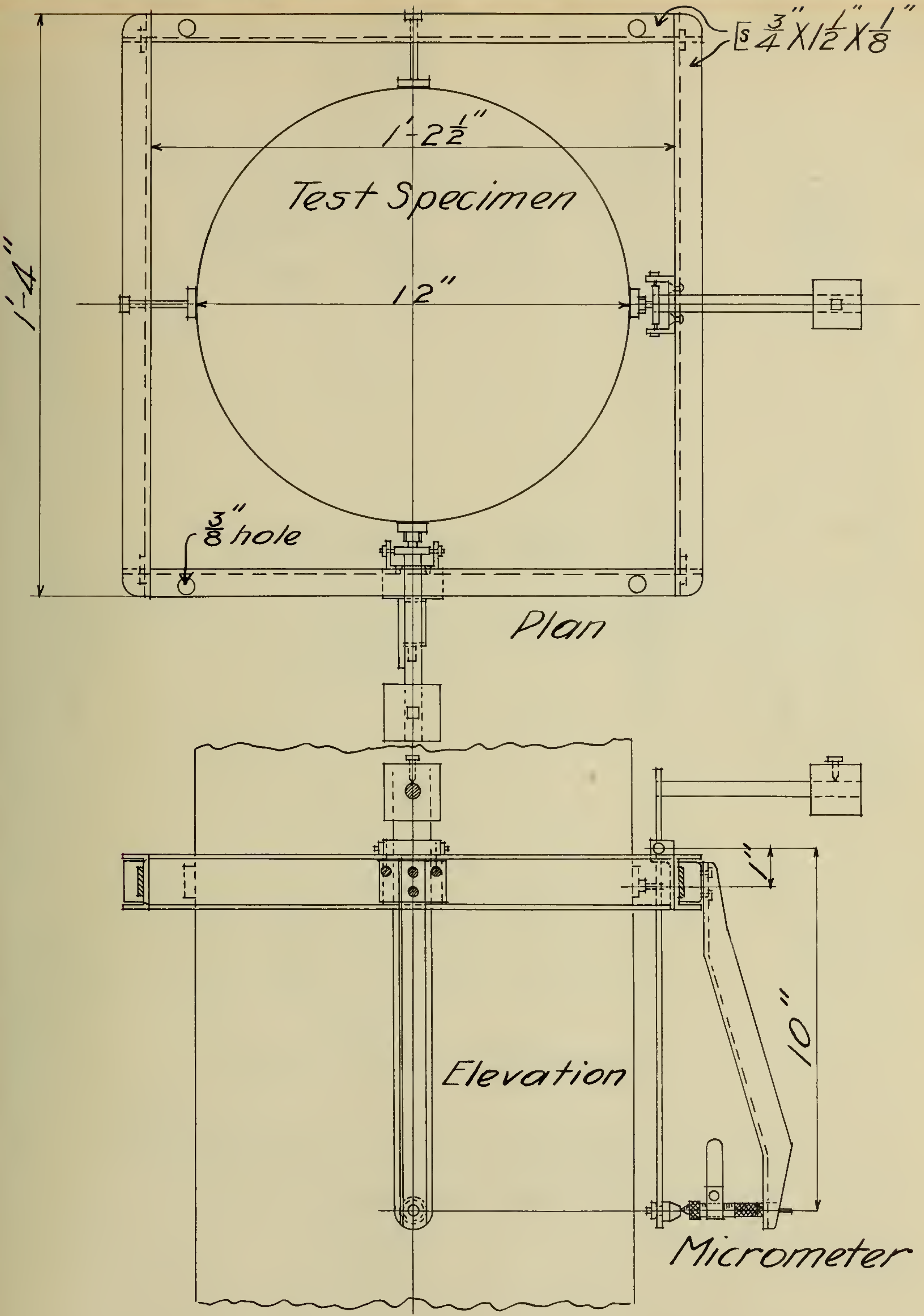
MEASURING DEVICES.

The instruments used to measure the longitudinal deformations were four extensometers which were devised and arranged for column tests. The instruments as shown in the figure are Johnson extensometer dials which read to ten thousanth of an inch. The dials were connected to the yokes at the top by contact rods, each yoke suspended two rods so two independent sets of instruments were read after each application of a load.

From center of yoke to center of dial is 100 inches, making the gauge length about 1 ft.-6 in. less than the height of the column. The yokes were placed four inches apart, which is the amount allowed for clearance, and attached to the dial of the corresponding portion at the bottom. The contact rods which worked on the axle or pinion of the dial are of white maple 3/8-in. by 3/4-in. in cross sections. At the bottom was attached a steel rod, convex on one side, this convex runner was held tightly against the axle by an elastic band, thus giving a perfect contact at all times.

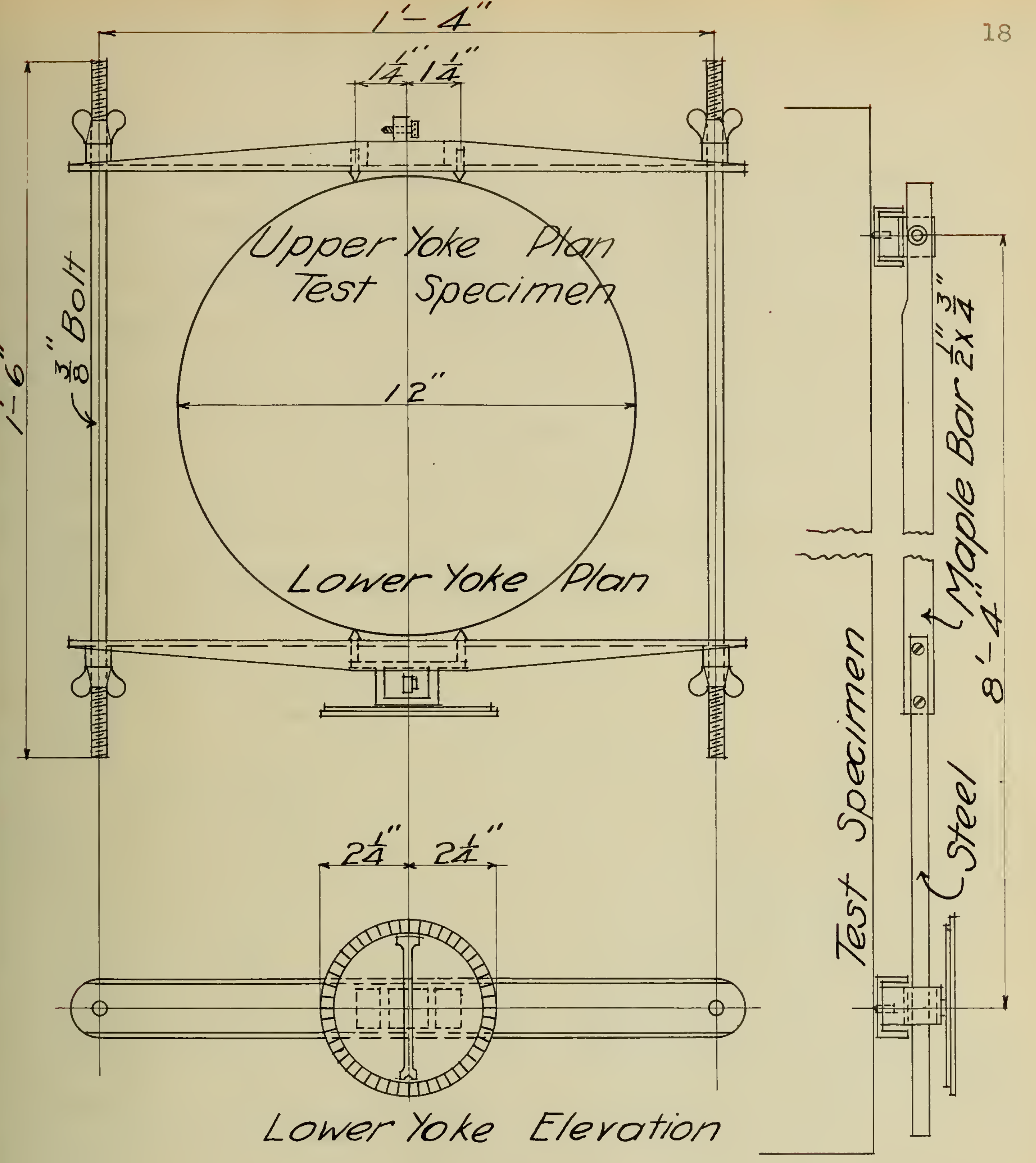
LATERAL EXPANSION.

The lateral expansion of the column during the test was measured by an Illinois Extensometer. Fig. . This instrument was designed by several of the men connected with the Engineering Experiment Station of the University of Illinois. The instrument is made of four small channels and placed around the center of the column, supported by a wooden yoke clamped around the column $8\frac{1}{2}$ inches above the center. By means of set screws, small iron discs are held against the column. The expansion is measured by micrometer screws attached to the end of a 10 by 1 lever arm. A dry battery circuit is closed when the point of the micrometer screw touches the end of the lever which has been moved out by the expanding column. An ordinary telephone receiver is used to determine the exact contact, as



Illinois Instrument for measuring lateral Deformation.

Fig. 2.



Longitudinal Extensometers
Used on Columns.
Fig. 3.

by this method greater accuracy is attained. The micrometer screws measure to one thousanths of an inch and one more place may be interpolated, making the actual readings to one ten-thousandth of an inch. The micrometer screws being on the long arm of a ten to one lever makes the actual deformation one tenth of the measured deformation so the expansion is measured in hundred-thousandths of an inch. The two micrometers read the expansion along the east and west diameter and also along the north and south diameter of the column.

GENERAL METHOD OF TESTING.

Several days in advance of the testing of a column it was capped with a steel plate, this plate is given an equal bearing surface by placing a cushion of plaster of paris between the plate and column. The bottom of the column has a base plate upon which the form was set and column made. Iron rods are then placed through slots in the part of the plate which extends beyond the column, and bolted. The columns are handled by means of overhead carriages, the piece is moved and placed in the machine in an upright position.

The load is transmitted through a spherical bearing block which is centered with respect to the column. The block being centered and the instruments attached an initial load of from 6000 to 11000 lb. was put on the column. With this load the initial readings of all the instruments was taken. The load

was then increased to the breaking load in increments of from 10000 to 25000 lb. The machine was stopped and the instruments read after each increment was added.

TABLE 9.

Summary of Columns.

Column Number	Mixture Volume	Mixture Weight	Age of Test Days	Cement	Reinforcement. Size of Band	Reinforcement. Per-cent
8121	1-1-2	1-1.34-2.33	60	Universal	No. 12	1.82
8122	1-1-2	1-1.24-2.11	63	Chicago AA	No. 12	1.77
8111	1-1-2	1-1.32-2.24	60	Universal	No. 20	0.65
8112	1-1-2	1-1.28-2.23	61	Chicago AA	No. 20	0.57
8131	1-1-2	1-1.37-2.18	15	Universal	5/16"	5.5
8179	1-2-4	1-2.61-4.41	14	Chicago AA	No. 12	1.76
8161	1-2-4	1-2.53-4.48	15	Universal	No. 20	0.63
8171	1-2-4	1-2.62-4.55	14	Universal	No. 20	0.58
8183	1-2-4	1-2.51-4.12	60	Universal	5/16"	~~0.52~~ 5.28
8184	1-2-4	1-2.55-4.38	60	Chicago AA	5/16"	5.28
8175	1-2-4	1-2.66-4.26	60	Universal	No. 12	1.82
8176	1-2-4	1-2.47-4.05	61	Chicago AA	No. 12	1.80
8251	1-2-4	1-2.94-4.89	60	Universal	No. 12	1.76
8252	1-2-4	1-2.45-4.01	69	Chicago AA	No. 12	1.76
8173	1-2-4	1-2.46-4.24	63	Universal	No. 12	1.80
8174	1-2-4	1-2.49-4.29	65	Universal	No. 12	1.83
8163	1-2-4	1-2.65-4.25	68	Universal	No. 20	0.58
8164	1-2-4	1-2.48-4.22	61	Universal	No. 20	0.56
8231	1-3-6	1-3.69-5.82	60	Universal	5/16"	5.28
8232	1-3-6	1-3.57-5.96	69	Chicago AA	5/16"	5.28
8221	1-3-6	1-4.04-6.45	60	Universal	No. 12	1.81
8222	1-3-6	1-3.73-6.45	71	Chicago AA	No. 12	1.76
8223	1-3-6	1-3.09-5.08	67	Chicago AA	No. 12	1.76
8211	1-3-6	1-3.57-8.23	60	Universal	No. 20	0.58
8212	1-3-6	1-3.58-6.23	61	Chicago AA	No. 20	0.62

GENERAL DESCRIPTION OF TESTS OF COLUMNS.

Column 8131:- This column was of 1-1-2 concrete reinforced with 5/16 in. bands and spaced 2 in. center to center, and received an initial load of 6500 lbs. and initial readings were taken on the instruments for this loading. The loading was increased to 600000 lbs. and then decreased by increments back to the initial loading. Repeated loadings were made until the test was discontinued after three hours and the test was continued after a 15 hour interval. After 1½ hours the column failed by the shifting of the bearing block causing the load to be applied off center.

Column 8183:- This column was of 1-2-4 concrete reinforced with 5/16 in. bands spaced 2 in. center to center and received an initial load of 6500 lbs. and initial readings were taken on the instruments for this loading. The column commenced spalling at 500000 lbs. Spalling occurred mostly in center third of column on south side of column. Failure occurred at 582000 lbs. This loading was held for five minutes and test was discontinued. Column was badly spalled on all sides.

Column 8179:- This column was of 1-2-4 concrete reinforced with No. 12 bands spaced 2 in. center to center and received an initial load of 6500 lbs. and initial readings were taken on all the instruments. Column began to spall at 105000 lbs. and the spalling became general at 170000 lbs. One hoop

broke near the bottom of the column at 175000 lbs. and one broke at the top at 178000 lbs. The column failed at 182000 lbs. by general crushing.

Column 8111:- This column of 1-1-2 concrete was reinforced by No. 20 bands spaced 2 in. center to center. Initial load of 6500 lbs. was applied and loads increased by increments of 25000 lbs. Spalling began at 400000 lbs. and slight vertical cracks were noticed. Column suddenly failed with explosive sound and was completely shattered for about 2 feet from the top. Bands were broken for about 1 foot in length beginning at 1 foot from the top. Maximum load carried was 425000 lbs.

Column 8163:- This column was of 1-2-4 concrete reinforced with No. 20 bands spaced 2 in. center to center and received an initial load of 6500 lbs. and initial readings were taken on all the instruments. The column started spalling at 202000 lbs. Failure occurred at about 4 feet from the top, 5 hoops breaking at the weld near top of column. Very little spalling took place excepting at the place of failure.

Column 8161:- This column was of 1-2-4 concrete reinforced with No. 20 bands spaced 2 in. center to center and received an initial load of 6500 lbs. and initial readings were taken on all the instruments. Surface cracks were noticed about 6 feet from the base. One hoop near bottom of column broke at 156000 lbs. This load being carried for several minutes a number of hoops broke at weld. Failure occurred about 3 feet from the bottom at 158000 lbs.

Column 8221:- This column was of 1-3-6 concrete reinforced with No. 12 bands spaced 2 in. center to center and received an initial load of 6500 lbs. and initial readings were taken on all the instruments. Spalling commenced at 225000 lbs. Failure occurred at 257000 lbs. by 2 hoops breaking, one 2 feet from bottom, the other $2\frac{3}{4}$ feet from the bottom.

Column 8122:- This column was of 1-1-2 concrete reinforced with No. 12 bands spaced 2 in. center to center and received an initial load of 5500 lbs. and initial readings were taken on the instruments for this loading. The column commenced spalling at 370000 lbs. total load. Failure occurred at a total load of 451000 lbs. by one hoop breaking at about the center of column and a general crushing midway between bands.

Column 8252:- This column was of 1-2-4 concrete reinforced with No. 12 bands spaced 2 in. center to center and received an initial load of 11000 lbs. and initial readings were taken on the instruments for this loading. The column commenced spalling at 140000 lbs., at 170000 lbs. tension cracks were observed, and at 190000 lbs. the bearing plate touched the base of the machine on the west side. The column failed at 209000 lbs. by general crushing. This column was loaded with an eccentricity of $1\frac{1}{4}$ inches.

Column 8171:- This column of 1-2-4 concrete was reinforced with No. 20 bands spaced 2 in. center to center. An initial load of 6500 lbs. was applied then by increments of

25000 lbs., 185000 lbs. was applied, the latter being the maximum load. The failure was due to the breaking of bands at the weld which occurred at the top of the column.

Column 8173:- This column of 1-2-4 concrete was reinforced with No. 12 bands spaced 2 in. center to center. A load of 6500 lbs. was applied as the initial load, then it was increased to 407000 lbs. by increments of 25000 lbs. Spalling began at 320000 lbs. From the maximum load of 407000 lbs. the load dropped off very slowly. The spalling was concentrated slightly above the center.

Column 8174:- This column of 1-2-4 concrete was reinforced with No. 12 hoops spaced 2 in. center to center. 65000 lbs. was applied as the initial load, then by increments of 25000 lbs. the load was increased to 437000 lbs. which was the breaking load. Spalling began at 340000 lbs. The failure was due to a rupture of a hoop at the center of the column. The bend was slight.

Column 8164:- This column was of 1-2-4 concrete reinforced with No. 12 bands spaced 2 in. center to center. An initial load of 6500 lbs. was used, then by increments of 25000 lbs. the maximum load was reached at 297000 lbs. A cracking noise was heard at 280000 lbs. followed by spalling. Hoops failed at maximum load about one foot from the top. The hoops failed at the welds in every case.

Column 8175:- This column was of 1-2-4 concrete reinforced with No. 12 bands spaced 2 in. center to center. 6500

lbs. was applied as the initial load, then by increments of 25000 lbs. the load was increased to 340000 lbs. which was the maximum load. Spalling began at 240000 lbs. and at 340000 lbs. a hoop broke, the load decreasing to 300000 lbs. The column was badly spalled.

Column 8231:- This column was of 1-3-6 concrete reinforced with 5/16 in. bands spaced 2 in. center to center. An initial load of 6500 lbs. was applied. The maximum load of 437000 lbs. was applied in increments of 25000 lbs. Spalling began at 187000 lbs. and continued to the failure of a hoop about 18 in. from the bottom, which occurred at a load of 437000 lbs.

Column 8211:- This column of 1-3-6 concrete was reinforced with No. 12 bands. An initial load of 6500 lbs. was taken. Owing to a mistake in machine speed the load was increased to 93000 lbs. before any readings were taken. At 140000 lbs. spalling commenced. At 155000 lbs. three hoops broke 6 inches from the bottom. The maximum load was 159000 lbs. No bending or crushing was noticeable.

Column 8212:- This column was of 1-3-6 concrete reinforced with No. 20 bands. An initial load of 6500 lbs. was taken and the loading was increased by increments of about 20000 lbs. Spalling began at 120000 lbs. and only a very slight spalling was noticeable. At 150000 lbs. a hoop broke at 2 feet from the bottom. At 155000 lbs. four hoops broke close to the bottom. This was the maximum load.

Column 8121:- This column was of 1-1-2 concrete reinforced with No. 12 bands spaced 2 in. center to center. An initial load of 6500 lbs. was put on and the loading was increased by increments of 25000 lbs. Spalling began at 475000 lbs. about one foot above the middle. One band broke on the north side about 1 foot below center at 545000 lbs. Column failed at 550000 lbs. by diagonal shear with loud explosive noise. One or two bands failed first then a number simultaneously.

Column 8176:- This column was of 1-2-4 concrete reinforced with No. 12 bands spaced 2 in. center to center. An initial load of 6500 lbs. was put on and the loading was increased by increments of 25000 lbs. Column began spalling at 300000 lbs. and spalled on east face at the center and also on the west face at top and bottom. Column failed at 415000 lbs. by a general crushing. There were no broken bands.

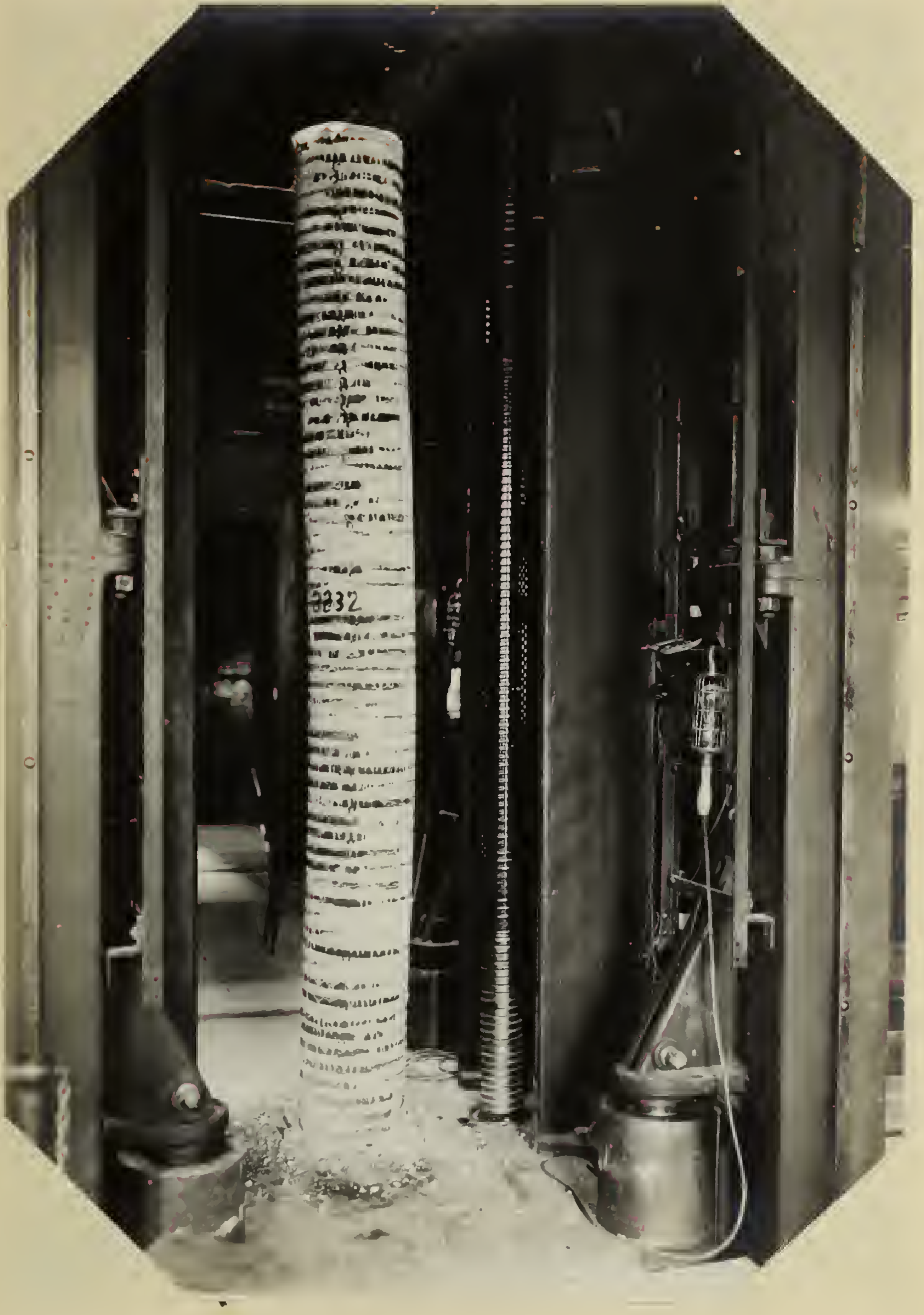
Column 8112:- This column of 1-1-2 concrete was reinforced with No. 20 bands spaced 2 in. center to center. The initial load was 6500 lbs. and the maximum load was 410000 lbs. The load was applied in increments of 25000 lbs. At the maximum load a total of eleven hoops near the bottom of the column failed at the weld.

Column 8184:- This column was of 1-2-4 concrete reinforced with 5/16 in. bands spaced 2 in. center to center. An initial load of 7000 lbs. was applied to the column, when zero readings were taken. By increments of 25000 lbs. the load was run up to 612000 lbs. which was the maximum load. The load then fell off to 560000 lbs. and the test was discontinued. A

general crushing of the concrete caused the failure as no hoop failed.

Column 8253:- This column was of 1-2-4 concrete reinforced with No. 12 bands spaced 2 in. center to center and was set with $1\frac{1}{4}$ in. of eccentricity. 6000 lbs. was applied as the initial load, then the load was increased by increments of 20000 lbs. up to 100000 lbs. From here the load was increased in increments of 15000 lbs. up to 174000 lbs. which was the maximum load. At 115000 lbs. tension cracks appeared on the side of columns near the center. Spalling began at 130000 lbs. and at 145000 lbs. the base plate was down on the floor.

Failure of Column due to bands breaking.



Failure due to crushing of concrete.

Failure due to bands breaking.

TABLE 10.

SUMMARY OF TESTS.

Column Number.	Mixture	Per-cent Rein.	Maximum Load. Lbs. Sq. In.	Ratio of Lateral to Longitudinal Deformation. ½ load	Max. load	Initial Modulus of Elasticity Lbs. Sq.In.	Manner of Failure.
8121	1-1-2	1.8	4860	1:10	1:3	4170000	Bands failed
8111	1-1-2	0.65	3750	1:9	1:9	3570000	Several bands failed.
8122	1-1-2	1.77	3980	1:7	1:4	5000000	General crushing
8112	1-1-2	0.57	3620	1:6	1:2	3300000	11 Bands failed at weld.
8131	1-2-4	5.5	5440	1:33	-----	4250000	Shifting of bearing block.
8179	1-2-4	1.76	1605	1:5	1:5	2000000	General crushing.
8161	1-2-4	0.63	1395	-----	1:4	2400000	Several bands failed at weld.
8171	1-2-4	0.58	1675	----	----	4300000	Bands failed at weld.
8183	1-2-4	~~0.53~~ 5.28	5140	1:5	-----	4600000	Test discontinued.
8184	1-2-4	5.28	5380	1:6	1:3	4800000	General crushing
8175	1-2-4	1.82	2990	1:7	1:5	3750000	Broken band.
8176	1-2-4	1.80	3660	1:5	1:3	3950000	General crushing.
8251	1-2-4	1.76	1405	1:7	1:4	3300000	Test discontinued
8252	1-2-4	1.76	1840	1:5	1:15	3120000	General crushing.
8173	1-2-4	1.80	3600	1:9	-----	4500000	Failure of concrete
8174	1-2-4	1.83	3860	1:8	1:3	4500000	Broken band.
8163	1-2-4	0.58	2560	1:13	1:7	3330000	5 Bands failed at welds.
8164	1-2-4	0.56	2610	1:13	1:3	3500000	Bands failed at weld.
8231	1-3-6	5.28	3750	1:7	1:10	2500000	Broken band.
8232	1-3-6	5.28	3750	1:6	1:4	2950000	General crushing.
8221	1-3-6	1.81	2270	1:21	1:4	3000000	2 Bands failed.
8222	1-3-6	1.76	1430	1:82	1:10	2000000	Band failed.
8223	1-3-6	1.76	1960	1:7	1:5	2250000	General crushing.
8211	1-3-6	0.58	1400	-----	-----	1670000	Bands failed.
8212	1-3-6	0.62	1365	1:9	1:4	2250000	4 Bands failed.

V.

DISCUSSION OF BAND HOOPED COLUMNS.

In this discussion no attempt will be made to enter into the theory of band hooped columns, but the different elements entering into the tests will be considered.

(a) Method of computing longitudinal stresses:- All stresses were assumed to be uniformly distributed over the entire section of the column and no account was taken of flexural stresses set up by the action of the column during the test.

(b) Comparison of percentage of reinforcement with compressive strength of columns.

This comparison is brought out clearly by means of Table 10. This table shows the comparison between the percentage reinforcement and the maximum unit load for columns made of different mixtures. The steel reinforcing bands are all approximately one inch wide and spaced 2 inches center to center.

(c) The ratio of the lateral to the longitudinal deformation:- The ratio of the lateral to the longitudinal deformation, called Poisson's ratio, is recorded in Table 10. This ratio was determined for the maximum load and also for one-half the maximum load. It will be seen that the ratio varies through quite a large range, for full load from 1:10 to 1:3 and at one-half load from 1:20 to 1:5. The ratio at half load for Column 8223 is 1:82 but this is the only one that anywhere near reaches such a figure. These ratios were found by dividing the unit lateral deformation by the unit longitudinal

deformation.

(d) Manner of failure:- Many of the columns failed on account of the hoops breaking, usually at the weld. Sometimes the hoops broke but not at the weld which showed that the steel was stressed above the elastic limit. Spalling occurred for some time before the final rupture and in some cases most of the concrete outside the reinforcement had fallen off before final rupture took place. Several columns failed by general crushing of the concrete but usually failure was due to breaking of the bands at the weld. The general method of failure may be seen in the photographs. In some cases there was a loud explosive sound at the time of failure, several bands breaking at one time.

(e) The initial modulus of elasticity and the method of computing it: The initial modulus of elasticity is recorded in Table 10 and was computed by drawing a tangent to the curve and dividing the ordinate in the scale of the unit loads by the abscissa in the scale of the unit deformation.

CONCLUSION.

To determine the effect of hooping columns a comparison between strengths of plain columns of different ages and mixtures and the columns of the same age and mixture but with different percentages of band reinforcement. The information relating to plain columns which was necessary for this comparison was obtained through the kindness of Burch and Heaney,

whose thesis treats of the plain concrete columns tested in this series. Table 11 shows the increase in strength in lbs. per square inch for an increase of 1 percent reinforcement of columns of different mixtures, ages and percent reinforcement.

TABLE 11.

INCREASE IN STRENGTH DUE TO REINFORCEMENT.

Mixture	Age at test Days.	Percent Reinforcement	Average Strength Lbs. per Sq. In.	Increase in Strength for increase of 1 percent Reinforcement. Lbs. Sq. In.
1 1 - 1 - 2	60	0.00	3485	
	60	.6	3685	335
	60	1.8	4420	520
			Average	428
1 - 2 - 4	14	0.0	900	
	14	.6	1535	1060
	14	1.8	1606	390
	14	5.5	5440	825
			Avorage	758
	60	0.0	2090	
	60	.57	2580	860
	60	1.8	2895	445
	60	5.3	5380	620
			Average	642
1 - 3 - 6	60	0.0	1100	
	60	.6	1380	460
	60	1.8	1885	435
	60	5.28	3750	500
			Average	465
		Grand	Average	578

COLUMN 8121

Observed Data

Length 10 ft. $0\frac{3}{4}$ in.
Gauge Length 100 in.
Circumference 3 ft. $3\frac{1}{4}$ in.

Mixture 1-1-2.
Age when tested, 60 days.
Cement, Universal.

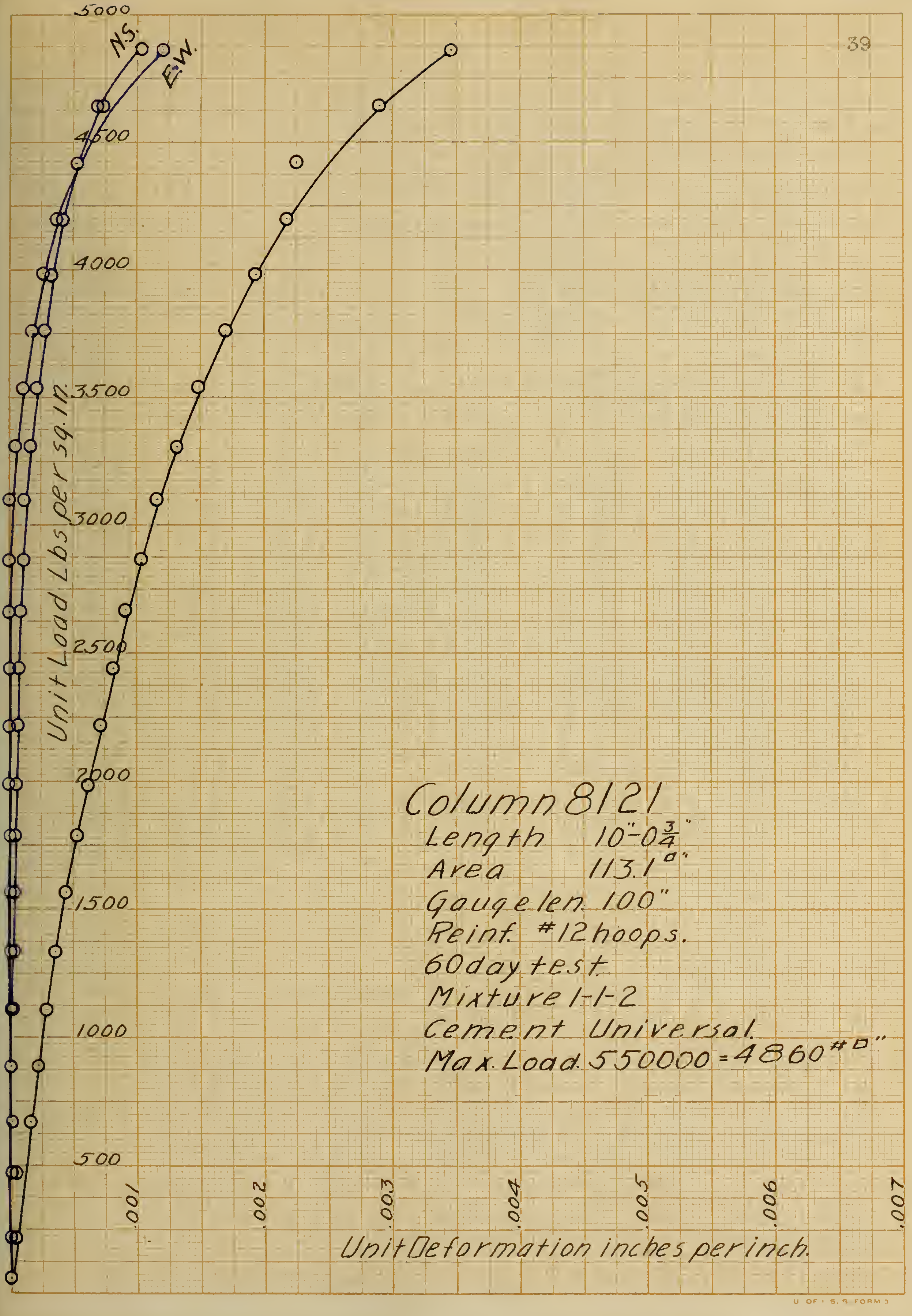
Reinforcement, No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings N.W.	S.W.	S.E.	N.E.	Lateral Extensometer E. W.	N. S.	Deflection N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2287	.2801	.00	.00
25000	.0040	.0030	.0035	.0046	.2529	.2790	.00	.00
53000	.0095	.0088	.0097	.0114	.2525	.2787	.00	.00
76000	.0145	.0151	.0172	.0168	.2516	.2784	.00	.00
101000	.0191	.0241	.0254	.0207	.2509	.2779	-.02	.00
126000	.0249	.0342	.0342	.0248	.2497	.2770	-.02	.00
151000	.0309	.0442	.0431	.0294	.2486	.2760	-.03	.01
176000	.0375	.0551	.0518	.0350	.2475	.2753	-.04	.01
201000	.0452	.0655	.0617	.0413	.2460	.2740	-.04	.02
225000	.0530	.0762	.0708	.0481	.2443	.2730	-.05	.02
251000	.0621	.0885	.0820	.0555	.2425	.2714	-.07	.02
276000	.0711	.1015	.0930	.0617	.2395	.2701	-.07	.02
302000	.0806	.1131	.1042	.0717	.2362	.2684	-.07	.02
325000	.0916	.1259	.1170	.0813	.2326	.2663	-.07	.02
350000	.1041	.1412	.1309	.0934	.2278	.2663	-.08	.03
375000	.1175	.1581	.1471	.1068	.2220	.2595	-.08	.03
401000	.1330	.1775	.1656	.1335	.2154	.2544	-.08	.03
425000	.1530	.2000	.1864	.1429	.2069	.2465	-.09	.03
450000	.1733	.2270	.2092	.1614	.1964	.2394	-.09	.03
475000	.1981	.2530	.2363	.1868	.1833	.2297	-.09	.03
500000	.2286	.2881	.2690	.2190	.1665	.2155	-.09	.03
525000	.2650	.3330	.3010	.2602	.1430	.1960	-.09	.03
550000	.3319	.4159	.3012	.3364	.0850	.1540	-.09	.03

COLUMN 8121

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation				Deflection
	100 ins.	1 in.	Total E. W.	Unit N. S.	Total E. W.	Unit N. S.	
57	.0000	.000000	.00000	.00000	.000000	.000000	.00
221	.0038	.000038	-.00242	.00011	-.000200	.000009	.00
470	.0099	.000099	-.00238	.00014	-.000197	.000012	.00
672	.0159	.000159	-.00229	.00017	-.000189	.000014	.00
892	.0223	.000223	-.00222	.00022	-.000184	.000018	.02
1110	.0295	.000295	-.00210	.00031	-.000173	.000026	.02
1335	.0369	.000369	-.00199	.00041	-.000164	.000034	.03
1565	.0450	.000450	-.00188	.00048	-.000155	.000040	.042
1785	.0534	.000534	-.00173	.00061	-.000143	.000050	.045
1990	.0620	.000620	-.00156	.00071	-.000130	.000059	.055
2220	.0720	.000720	-.00137	.00087	-.000113	.000072	.074
2440	.0818	.000818	-.00108	.00100	-.000089	.000083	.074
2670	.0924	.000924	-.00075	.00117	-.000062	.000097	.074
2870	.1040	.001040	-.00039	.00138	-.000032	.000114	.074
3100	.1174	.001174	.00009	.00138	.000008	.000114	.086
3310	.1324	.001324	.00067	.00206	.000055	.000170	.086
3540	.1499	.001499	.00133	.00257	.000110	.000212	.086
3760	.1706	.001706	.00218	.00336	.000180	.000278	.096
3980	.1930	.001930	.00323	.00407	.000267	.000336	.096
4200	.2186	.002186	.00454	.00504	.000375	.000416	.096
4420	.2512	.002512	.00622	.00646	.000513	.000535	.096
4640	.2898	.002898	.00857	.00841	.000708	.000695	.096
4860	.3464	.003464	.01437	.01261	.001186	.001040	.096



Column 8121
Length 10'-0¾"
Area 113.1 □"
Gauge len. 100"
Reinf. #12 hoops.
60 day test.
Mixture 1-1-2
Cement Universal.
Max. Load 550000 = 4860 #□"

COLUMN 8122

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Circumference 3 ft. 3 3/8 in.

Mixture 1-1-2.
Age when tested, 60 days.
Cement, Chicago AA.

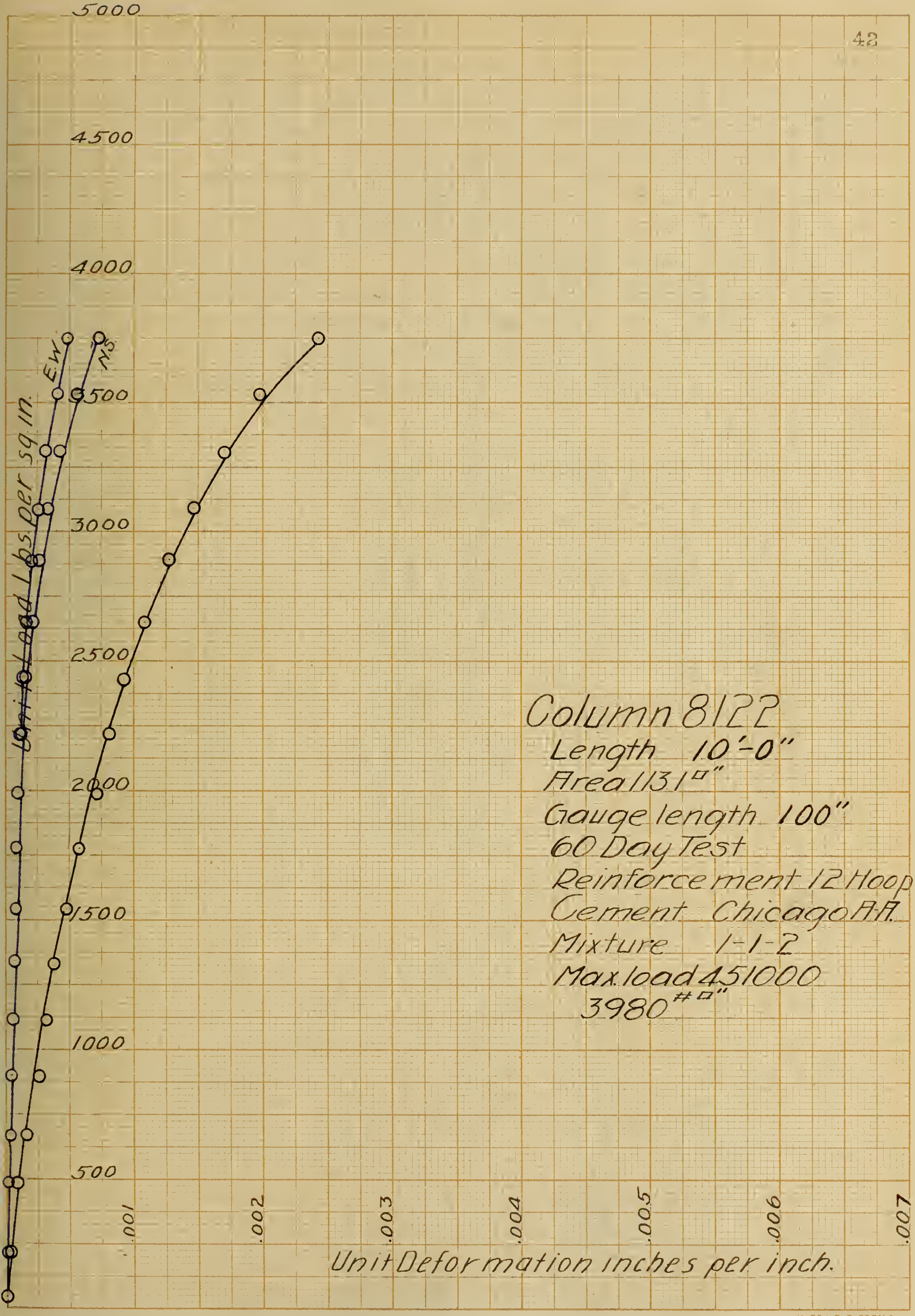
Reinforcement, No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
5500	.0000	.0000	.0000	.0000	.2901	.2580	.00	.00
25000	.0039	.0022	.0033	.0048	.2895	.2567	.00	.00
55000	.0095	.0082	.0087	.0119	.2885	.2556	.00	.00
76000	.0155	.0138	.0156	.0195	.2869	.2544	.00	.00
102000	.0220	.0218	.0225	.0281	.2857	.2534	.00	.00
127000	.0292	.0298	.0306	.0365	.2845	.2524	.00	.00
151000	.0350	.0382	.0387	.0458	.2830	.2509	.02	.00
175000	.0435	.0468	.0467	.0563	.2818	.2499	.03	.00
201000	.0522	.0562	.0574	.0683	.2799	.2476	.04	.00
225000	.0610	.0662	.0776	.0808	.2778	.2450	.04	.00
251000	.0712	.0780	.0792	.0963	.2745	.2418	.04	.00
275000	.0820	.0890	.0909	.1111	.2724	.2384	.05	.00
300000	.0950	.1040	.1049	.1297	.2693	.2333	.06	.02
328000	.1132	.1210	.1240	.1541	.2640	.2256	.08	.03
350000	.1300	.1375	.1422	.1787	.2585	.2175	.09	.04
375000	.1504	.1565	.1667	.2085	.2509	.2059	.10	.05
400000	.1790	.1800	.1885	.2452	.2405	.1913	.12	.06
425000	.2140	.2080	.2232	.2921	.2301	.1698	.15	.08
451000	Maximum Load.							

COLUMN 8122

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation E. W.		N. S.		Deflection
	100 ins.	1 in.	Total	Unit	Total	Unit	
48.6	.0000	.000000	.00000	.000000	.00000	.000000	.00
221.0	.0035	.000035	.00006	.000005	.00013	.000011	.00
486.0	.0096	.000096	.00016	.000013	.00024	.000020	.00
672	.0161	.000161	.00032	.000026	.00036	.000030	.00
900	.0238	.000238	.00044	.000036	.00046	.000038	.00
1120	.0315	.000315	.00056	.000046	.00056	.000046	.02
1330	.0394	.000394	.00071	.000059	.00071	.000059	.03
1545	.0483	.000483	.00083	.000069	.00081	.000067	.04
1775	.0585	.000585	.00102	.000084	.00104	.000086	.04
1987	.0714	.000714	.00123	.000102	.00130	.000107	.04
2220	.0812	.000812	.00156	.000129	.00162	.000134	.04
2430	.0932	.000932	.00177	.000146	.00196	.000162	.05
2650	.0184	.001084	.00208	.000172	.00247	.000204	.065
2890	.1281	.001281	.00261	.000216	.00324	.000268	.087
3090	.1471	.001471	.00316	.000260	.00405	.000335	.10
3310	.1705	.001705	.00392	.000324	.00521	.000430	.115
3530	.1982	.001982	.00496	.000410	.00677	.000560	.135
3750	.2443	.002443	.00600	.000495	.00882	.000730	.17
3980							



Column 8122
Length 10'-0"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement 12 Hoop
Cement Chicago A.A.
Mixture 1-1-2
Max. load 451000
3980#□"

COLUMN 8111

Observed Data

Length 10 ft. 1¼ in.	Mixture 1-1-2.
Gauge Length 100 in.	Age when tested, 60 days.
Circumference 3 ft. 3¼ in.	Cement, Universal.

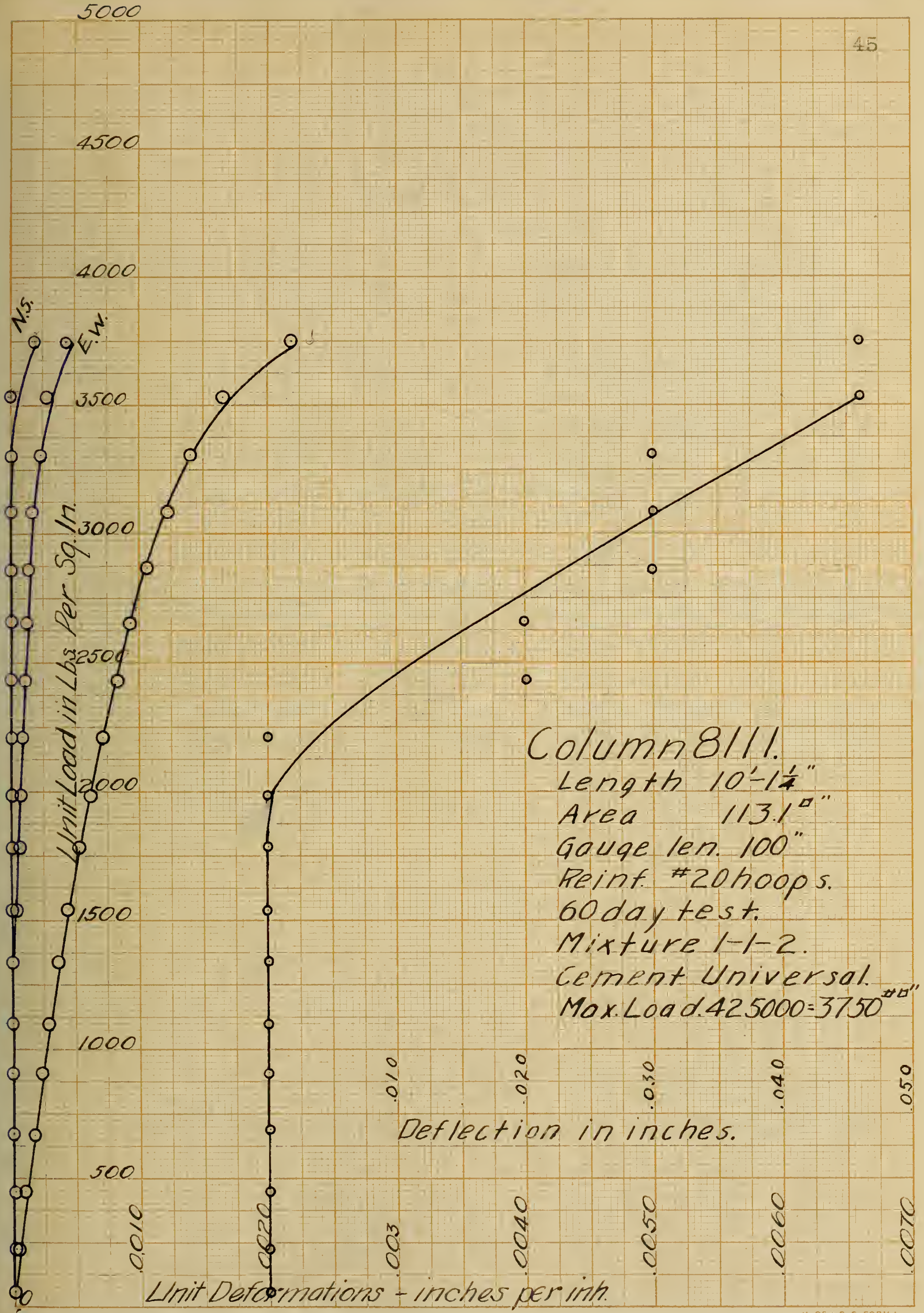
Reinforcement, No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000		.0000	.0000	.2698	.2664	.00	.00
25500	.0035		.0044	.0046	.2695	.2665	.00	.00
51000	.0092		.0094	.0102	.2697	.2665	.00	.00
76000	.0175		.0140	.0182	.2686	.2664	.00	.00
103000	.0260		.0198	.0276	.2678	.2667	.00	.00
125000	.0330		.0254	.0352	.2665	.2673	.00	.00
152000	.0416		.0324	.0446	.2660	.2686	.00	.00
175000	.0505		.0392	.0534	.2645	.2702	.00	.00
202000	.0602		.0472	.0632	.2625	.2718	.00	.00
225000	.0690		.0554	.0732	.2611	.2735	.00	.00
250000	.0792		.0646	.0834	.2593	.2764	.00	.00
275000	.0908		.0748	.0952	.2570	.2785	.02	.00
301000	.1030		.0858	.1076	.2550	.2800	.02	.00
325000	.1160		.0980	.1214	.2520	.2809	.03	.00
350000	.1320		.1134	.1370	.2488	.2790	.03	.00
375000	.1500		.1308	.1574	.2435	.2751	.03	.00
400000	.1755		.1574	.1862	.2357	.2668	.04	-.02
425000	.2250		.2126	.2394	.2182	.2430	.04	-.02

COLUMN 8111

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total E. W.	Lateral Deformation Total N. S.	Lateral Deformation Unit E. W.	Lateral Deformation Unit N. S.	Deflection
57	.0000	.0000000	.00000	.00000	.000000	.000000	.00
225	.0040	.000040	.00003	-.00001	.000002	-.000001	.00
450	.0093	.000093	.00001	-.00001	.000001	-.000001	.00
670	.0158	.000158	.00012	.00000	.000010	.000000	.00
910	.0229	.000229	.00028	-.00003	.000023	-.000002	.00
1100	.0292	.000292	.00033	-.00009	.000027	-.000007	.00
1340	.0370	.000370	.00038	-.00022	.000032	-.000018	.00
1545	.0449	.000449	.00053	-.00038	.000044	-.000032	.00
1780	.0537	.000537	.00073	-.00054	.000061	-.000044	.00
1990	.0622	.000622	.00087	-.00071	.000072	-.000059	.00
2210	.0719	.000719	.00105	-.00100	.000087	-.000083	.00
2430	.0828	.000828	.00128	-.00121	.000107	-.000101	.02
2660	.0944	.000944	.00148	-.00136	.000132	-.000113	.02
2870	.1070	.001070	.00178	-.00145	.000148	-.000121	.03
3090	.1227	.001227	.00210	-.00126	.000175	-.000105	.03
3310	.1404	.001404	.00283	-.00087	.000236	-.000072	.03
3530	.1665	.001665	.00341	-.00004	.000282	-.000003	.046
3750	.2188	.002188	.00516	.00234	.000430	.000195	.046



Column 8111.
Length 10'-1¼"
Area 113.1□"
Gauge len. 100"
Reinf. #20 hoops.
60 day test.
Mixture 1-1-2.
Cement Universal.
Max. Load. 425000=3750#□"

COLUMN 8112

Observed Data

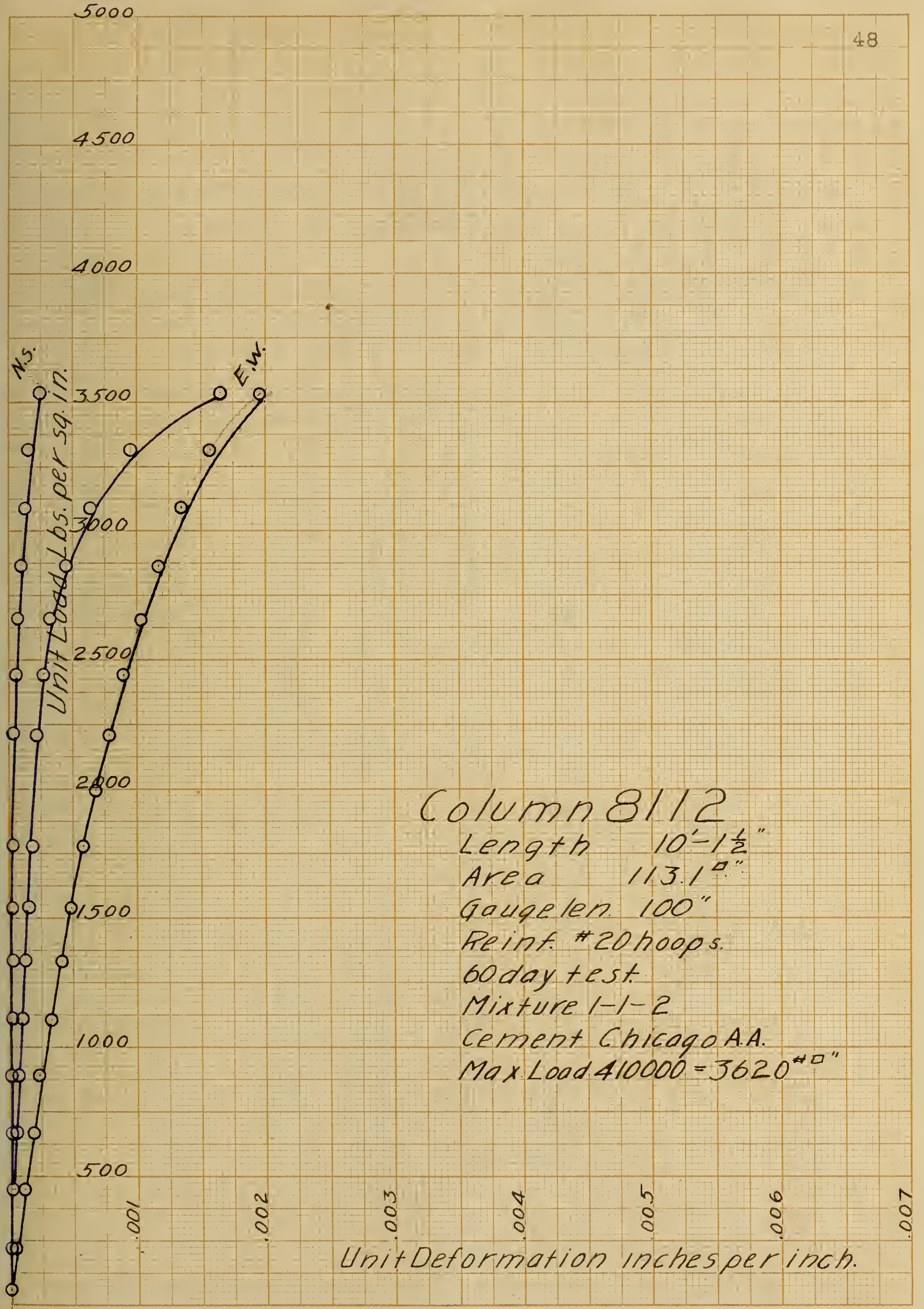
Length 10 ft. 1½ in. Mixture 1-1-2.
Gauge Length 100 in. Age when tested, 60 days.
Circumference 3 ft. 3¼ in. Cement, Chicago AA.
Reinforcement, No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2804	.2618	.00	.00
25000	.0051	.0025	.0040	.	.2794	.2603	.00	.00
51000	.0118	.0077	.0102	.0020	.2778	.2601	.00	.00
76000	.0181	.0134	.0179	.0105	.2760	.2580	.00	.00
101000	.0250	.0209	.0248	.0110	.2737	.2592	.00	.00
125000	.0337	.0291	.0318	.0185	.2713	.2593	.00	.00
151000	.0419	.0369	.0395	.0260	.2684	.2589	.01	-.01
175000	.0505	.0448	.0478	.0352	.2654	.2581	.02	-.02
201000	.0599	.0538	.0572	.0455	.2617	.2584	.02	-.02
226000	.0692	.0621	.0662	.0555	.2578	.2577	.02	-.02
250000	.0790	.0706	.0780	.0678	.2536	.2571	.63	-.02
276000	.0901	.0822	.0892	.0800	.2485	.2541	.03	-.02
301000	.1030	.0932	.1028	.0940	.2412	.2537	.03	-.02
325000	.1160	.1061	.1178	.1120	.2263	.2497	.03	-.02
350000	.1331	.1220	.1370	.1308	.2028	.2461	.03	-.02
375000	.1535	.1417	.1610	.1520	.1658	.2420	.04	-.02
400000	.1909	.1764	.2010	.2005	.0922	.2315	.04	-.00
410000	Maximum Load.							

COLUMN 8112

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total E. W.	Lateral Deformation Total N. S.	Lateral Deformation Unit E. W.	Lateral Deformation Unit N.S.	Deflection
57	.0000	.000000	.00000	.00000	.000000	.000000	.00
221	.0046	.000046	.00010	.00015	.000008	.000012	.00
450	.0110	.000110	.00026	.00017	.000022	.000014	.00
671	.0180	.000180	.00044	.00038	.000037	.000032	.00
890	.0249	.000249	.00067	.00026	.000056	.000022	.00
1105	.0328	.000328	.00091	.00025	.000076	.000022	.00
1330	.0407	.000407	.00120	.00029	.000100	.000024	.01
1545	.0497	.000497	.00150	.00037	.000125	.000031	.028
1780	.0586	.000586	.00187	.00034	.000156	.000028	.028
2000	.0677	.000677	.00226	.00041	.000188	.000034	.028
2210	.0785	.000785	.00268	.00047	.000224	.000039	.037
2440	.0897	.000897	.00319	.00077	.000266	.000064	.037
2660	.1029	.001029	.00392	.00081	.000326	.000068	.037
2870	.1169	.001169	.00541	.00121	.000450	.000101	.037
3090	.1351	.001351	.00776	.00157	.000647	.000130	.037
3315	.1573	.001573	.01146	.00198	.000955	.000165	.046
3530	.1960	.001960	.01982	.00303	.001650	.000252	.046
3620	Maximum Load.						



Column 8112

Length 10'-1½"

Area 113.1□"

Gauge len. 100"

Reinf. #20 hoops.

60 day test.

Mixture 1-1-2

Cement Chicago A.A.

Max Load 410000 = 3620#□"

COLUMN 8131

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Dimensions, Cir. 3 ft.-$4\frac{3}{4}$ in.

Mixture 1-2-4.
Age when tested, 14 days.
Cement, Universal.

Reinforcement 5/16 in. Steel Hoops.

Load Pounds	Longitudinal Extensometer Readings 1	2	3	4	Transverse Extensometer Readings
6500	.0000	.0000	.0000	.0000	.0127
22500	.0022	.0038	.0000	.0062	.0129
52500	.0056	.0092	.0020	.0170	.0131
77000	.0182	.0132	.0050	.0252	.0132
102000	.0254	.0180	.0092	.0332	.0132
122500	.0314	.0230	.0134	.0396	.0133
151000	.0396	.0310	.0200	.0492	.0135
175000	.0458	.0382	.0254	.0560	.0135
201000	.0528	.0470	.0334	.0644	.0135
225000	.0590	.0542	.0408	.0716	.0136
250000	.0662	.0644	.0486	.0794	.0137
276000	.0748	.0740	.0578	.0880	.0138
301000	.0830	.0844	.0666	.0980	.0140
324000	.0920	.0958	.0763	.1084	.0140
351000	.1036	.1088	.0866	.1208	.0141
378000	.1164	.1226	.0998	.1348	.0142
400000	.1260	.1252	.1100	.1476	.0143
428000	.1410	.1538	.1242	.1656	.0143
450000	.1550	.1698	.1380	.1832	.0145
475000	.1712	.1932	.1756	.2050	.0145
501000	.1880	.2172	.1760	.2246	.0145
525000	.2168	.2456	.1974	.2596	.0145
550000	.2458	.2800	.2226	.2960	.0147
575000	.2836	.3258	.2556	.3438	.0148
600000	.3230	.3742	.2900	.3940	.0148
496000	.3120	.3658	.2806	.3840	
405000	.2930	.3490	.2650	.3640	
300000	.2660	.3240	.2420	.3360	
200000	.2380	.2950	.2160	.3050	
100000	.1980	.2550	.1810	.2600	
6500	.1380	.1660	.1150	.1750	
99000	.1700	.1970	.1390	.2130	
198000	.2100	.2370	.1740	.2590	

COLUMN 8131

Observed Data

Continued

Load Pounds	Longitudinal Extensometer Readings				Transverse Extensometer Readings
	S.E	N.W.	S.W	N.E.	
300000	.2470	.2760	.2120	.3020	
395000	.2820	.3120	.2370	.3400	
500000	.3170	.3500	.2090	.3810	
600000	.3710	.4090	.3120	.4440	
400000	.3360	.3750	.2800	.4070	
200000	.2970	.3210	.2320	.3470	
6500	.1670	.1900	.1300	.2060	
582000	.3940	.4300	.3160	.4750	
6500	.1810	.2000	.1330	.2210	
590000	.4220	.4620	.3260	.5140	
6500	.2010	.2160	.1390	.2470	
595000	.4410	.4850	.3300	.5440	
6500	.2150	.2330	.1420	.2690	
595000	.4570	.5050	.3330	.5710	
6500	.2190	.2300	.1390	.2710	
596000	.5490	.4800	.3380	.6200	
6500	.2880	.2410	.1510	.3290	
12000	.2700	.2290	.1460	.3190	
603000	.6000	.4550	.3300	.6410	
6500	.3380	.2460	.1640	.3660	
615000	.8560	.4560	.3370	.6830	
6500	.5720	.2500	.1700	.3830	
600000	1.0730	.4460	.3320	.7040	
6500	.7850	.2470	.1700	.4080	
603000	1.0730	.4440	.3320	.7270	
6500	.7670	.2450	.1710	.4240	
600000	1.0740	.4360	.3300	.7620	
6500	.7620	.2430	.1700	.4480	
603000	1.0760	.4260	.3250	.8020	
6500	.7330	.2270	.1590	.4690	
600000	1.1620	.3850	.2950	.8650	
6500	.8220	.1840	.1380	.5170	
600000	Failed - load dropped to 480000.				

COLUMN 8131

Computed Data

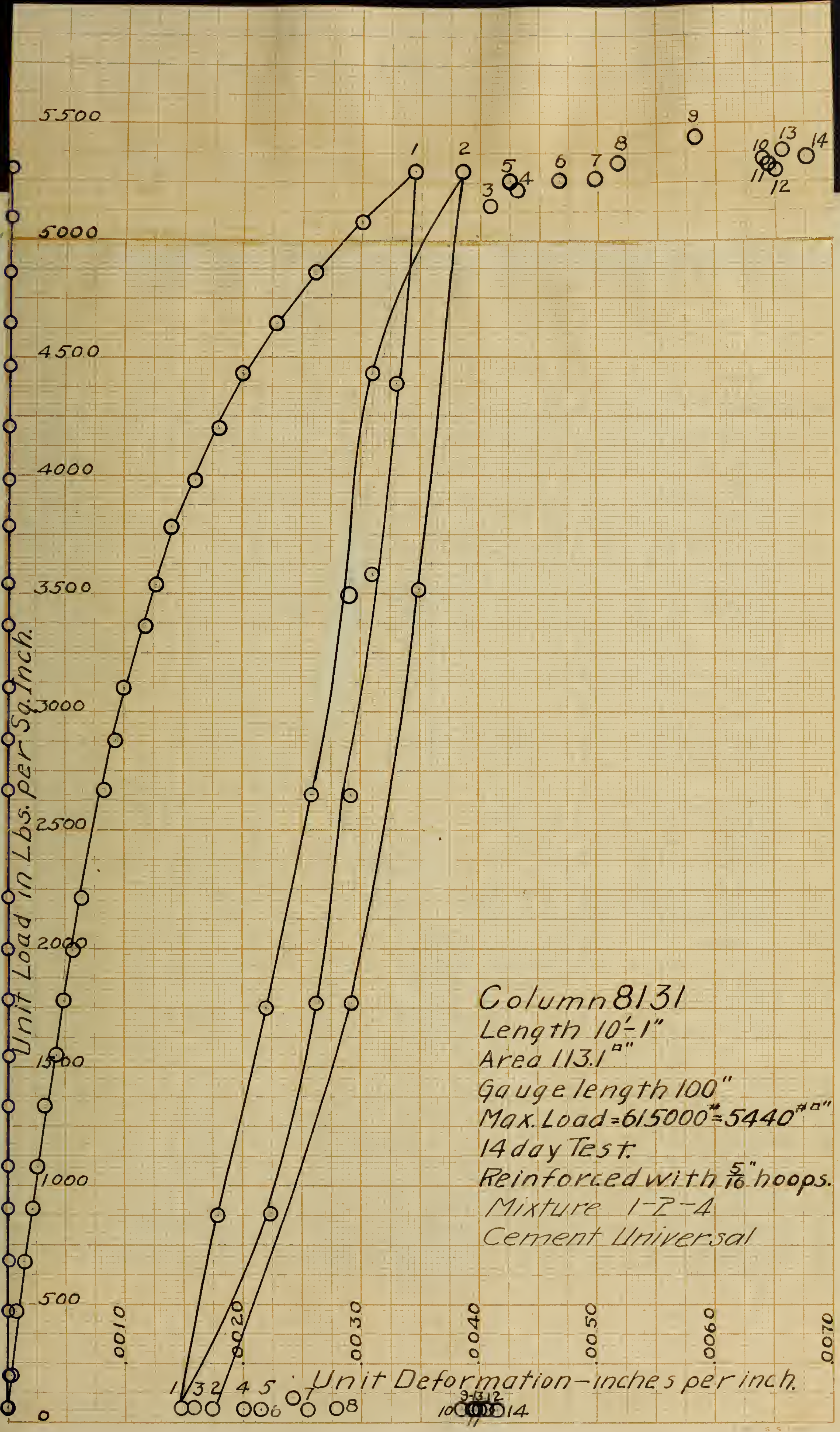
Unit Load Lbs. per sq in.	Longitudinal Deformation per		Lateral Deformation	
	100 ins.	1 in.	Total	Unit
57	.00000	.000000	.000000	.000000
199	..00305	.000030	.000047	.0000036
464	.00845	.000084	.000094	.0000072
680	.01540	.000154	.000118	.0000091
900	.02145	.000214	.000118	.0000091
1080	.02685	.000268	.000140	.0000108
1335	.03495	.000350	.000187	.0000144
1550	.04385	.000438	.000187	.0000144
1780	.04940	.000494	.000187	.0000144
1990	.05640	.000564	.000212	.0000163
2210	.06440	.000644	.000235	.0000180
2440	.07365	.000736	.000260	.0000200
2660	.08300	.000830	.000330	.0000254
2879	.09320	.000932	.000330	.0000254
3100	.10495	.001050	.000332	.0000256
3360	.11840	.001184	.000334	.0000257
3540	.12720	.001272	.000336	.0000258
3780	.14615	.001462	.000336	.0000258
3980	.16150	.001615	.000341	.0000262
4200	.18625	.001862	.000341	.0000262
4430	.20145	.002014	.000341	.0000262
4640	.22985	.002298	.000341	.0000262
4860	.26110	.002611	.000346	.0000266
5080	.30220	.003022	.000348	.0000268
5300	.34530	.003453	.000348	.0000268
4390	.33560	.003356		
3580	.3178	.003178		
2650	.2920	.002920		
1770	.2635	.002635		
883	.2235	.002235		
57	.1485	.001485		
875	.1798	.001798		
1750	.2200	.002200		
2650	.25925	.002592		
3490	.29275	.002928		
4430	.31425	.003142		
5300	.3840	.003840		
3520	.3495	.003495		

COLUMN 8131

Computed Data

Continued

Unit Load Lbs. per sq in.	Longitudinal Deformation per	
	100 ins.	1 in.
1770	.2925	.002925
57	.17325	.001732
5150	.40375	.004037
57	.15875	.001588
5220	.4310	.004310
57	.20075	.002008
5260	.4250	.004250
57	.21475	.002148
5260	.4665	.004665
57	.21475	.002148
5270	.49675	.004968
57	.25475	.002548
106	.2410	.002410
5330	.5165	.005165
57	.2785	.002785
5440	.5830	.005830
57	.39375	.003938
5300	.63875	.006388
57	.3850	.003850
5330	.6440	.006440
57	.40175	.004018
5300	.6505	.006505
57	.40575	.004058
5330	.65725	.006572
57	.3970	.003970
5300	.67675	.006768
57	.41425	.004152
5300	Failed - Load dropped to 480000	



Column 8131
Length 10'-1"
Area 113.1□"
Gauge length 100"
Max. Load = 615000# = 5440#□"
14 day Test.
Reinforced with $\frac{5}{16}$" hoops.
Mixture 1-2-4
Cement Universal

COLUMN 8179

Observed Data

Length 9 ft. 11 in.
Gauge Length 100 in.
Circumference 3 ft. 3 in.

Mixture 1-2-4.
Age when tested, 14 days.
Cement, Chicago AA.

Reinforcement, No. 12 Hoops.

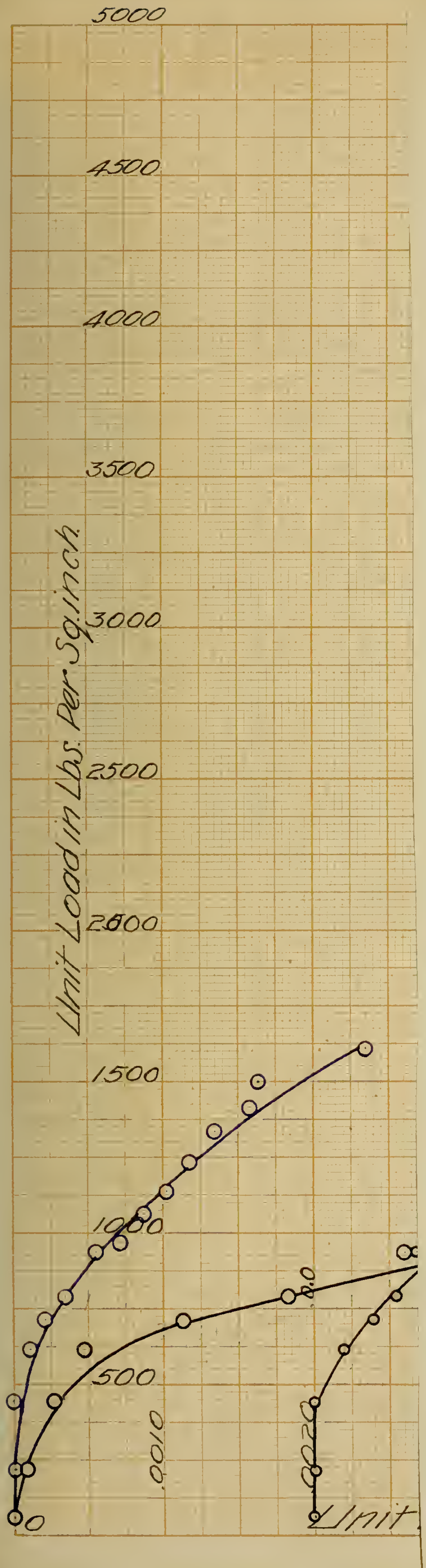
Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2871	.2536	.00	.00
25000	.0085	.0070	.0087	.0099	.2859	.2517	.00	.00
50000	.0258	.0215	.0327	.0274	.2830	.2488	.00	.00
70000	.0720	.0620	.0853	.0688	.2780	.2378	.02	.00
80000	.1150	.0975	.1304	.1125	.2722	.2185	.04	.01
90000	.1855	.1620	.2040	.1823	.2688	.1868	.05	.02
100000	.2770	.2320	.2810	.2587	.2453	.1620	.06	.03
110000	.3440	.3140	.3744	.3495	.2340	.1352	.07	.04
120000	.4350	.4050	.4785	.4489	.2198	.1081	.12	.07
130000	.5350	.5025	.5513	.5578	.2055	.0854	.14	.09
140000	.6390	.6040	.6374	.6770	.1908	.0645	.20	.11
151000	.7610	.7190	.7755	.8143	.1755	.0391	.28	.17
160000	.8790	.8250	.9187	.9483	.1610	.0070	.36	.20
170000	.9850	.9260	.9990	1.0850	.1450	.9075	.48	.28
182000	1.2090	1.0220	1.0338	1.4223	.0870*	.1775**	.75	.64
182000	Maximum Load							

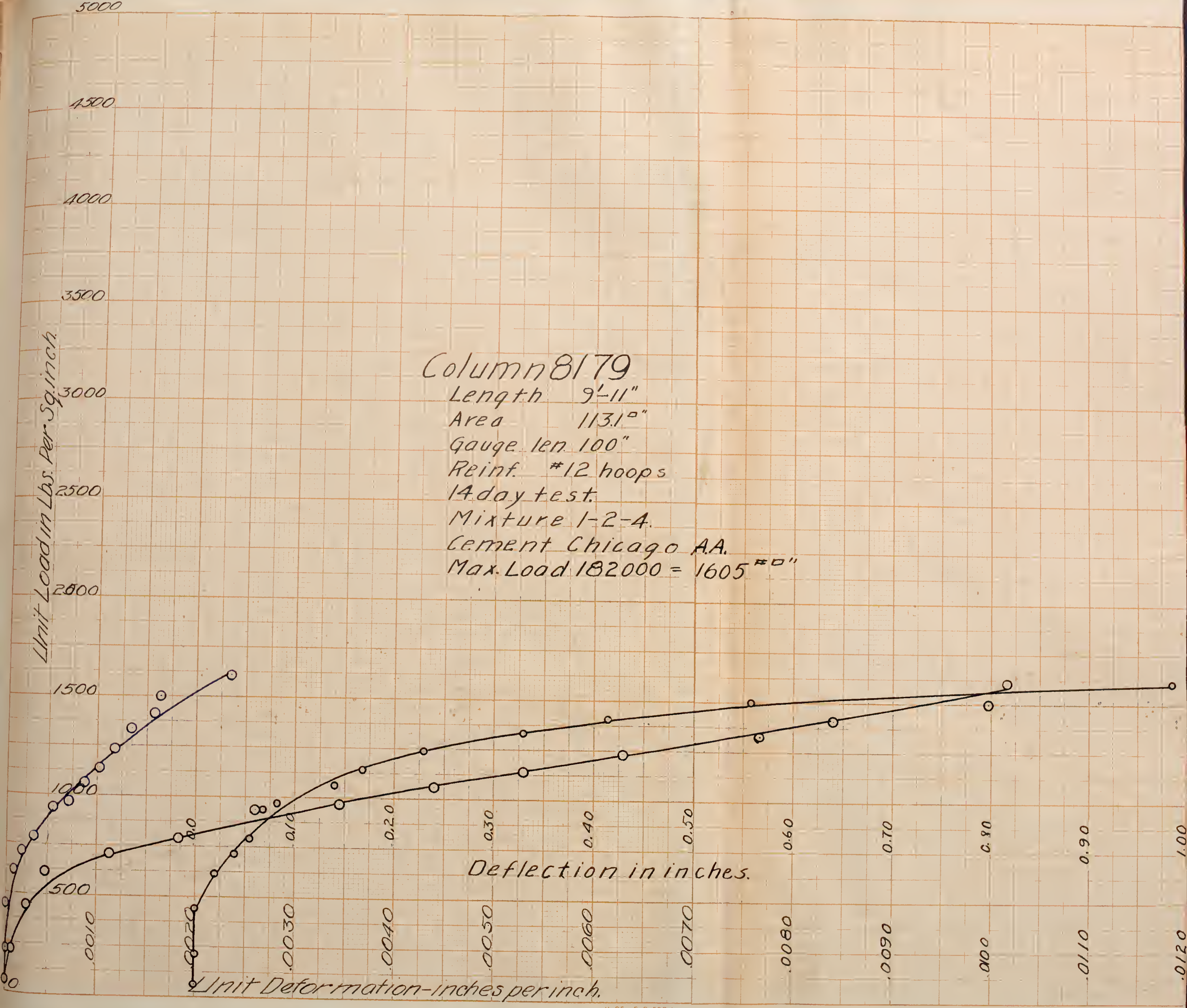
*.2155 (Reset)
**.2220 (Reset)

COLUMN 8179

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per		Lateral Deformation		Deflection
	100 ins.	1 in.	Total	Unit	Inches
57.4	.0000	.000000	.000000	.000000	.00
222	.0085	.000085	.000155	.000013	.00
442	.0268	.000268	.000445	.000037	.00
618	.0720	.000720	.001245	.000103	.02
705	.1138	.001138	.002500	.000206	.041
794	.1829	.001829	.004255	.000350	.055
882	.2622	.002622	.006670	.000550	.068
970	.3455	.003455	.008575	.000710	.082
1060	.4418	.004418	.010640	.000880	.140
1140	.5366	.005366	.012490	.001030	.168
1230	.6392	.006392	.014270	.001180	.230
1330	.7674	.007674	.016305	.001350	.330
1410	.8927	.008927	.019135	.001580	.414
1500	.9987	.009987	.019910	.001646	.557
1605	1.1718	.011718	.028560	.002355	.985
1605	Maximum Load.				


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Unit Load in Lbs. Per Sq. inch
.0010
.0020
Unit



Column 8179
Length 9'-11"
Area 113.1□"
Gauge len. 100"
Reinf. #12 hoops
14 day test.
Mixture 1-2-4.
Cement Chicago A.A.
Max. Load 182000 = 1605 #□"

COLUMN 8161

Observed Data

Length 10 ft. $0\frac{1}{4}$ in.
Gauge Length 100 in.
Dimensions, C 3 ft 3 in.

Mixture 1-2-4.
Age when tested, 14 days.
Cement, Universal.

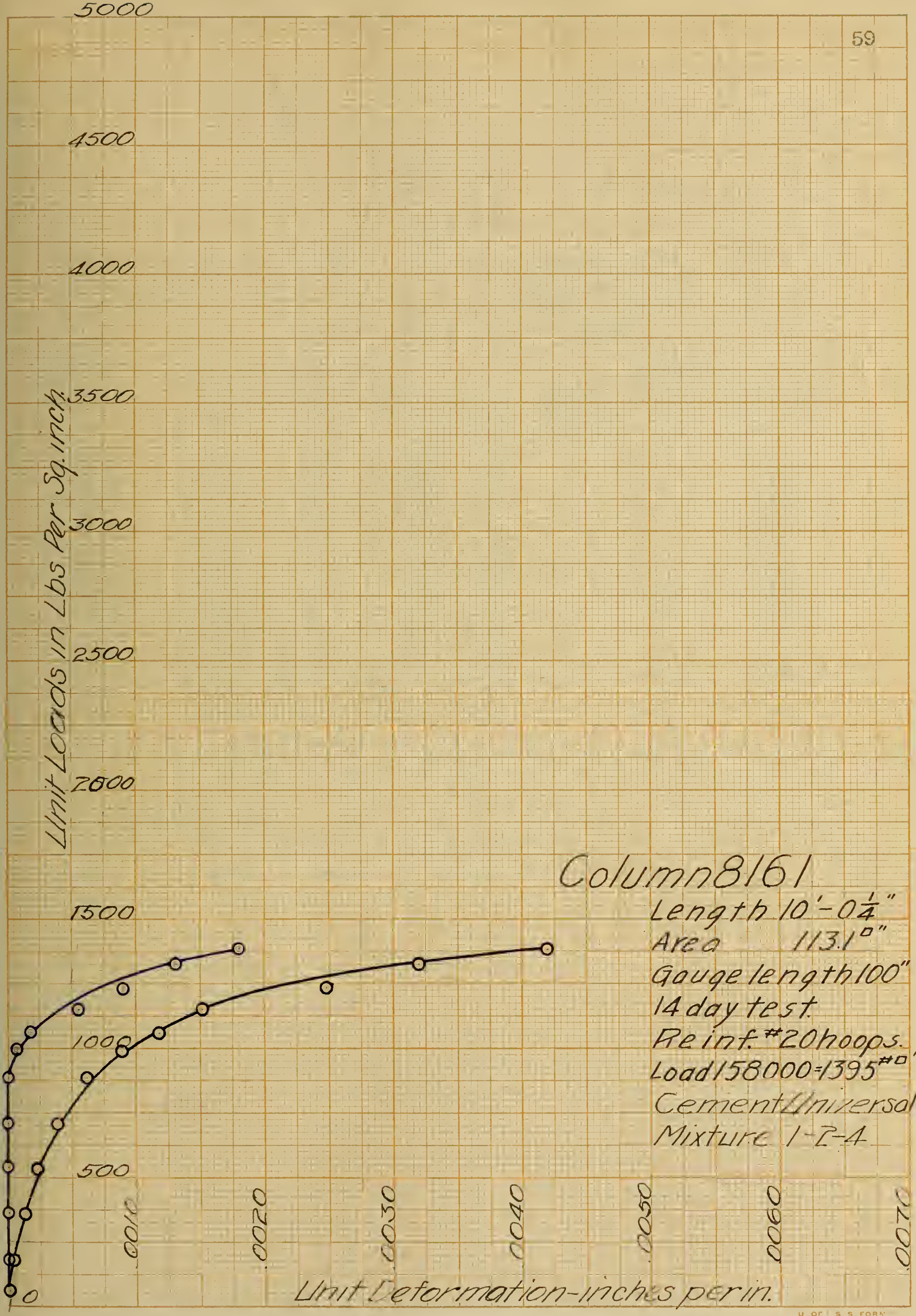
Reinforcement, No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer Readings	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.
6500	.0000	.0000	.0000	.0000	.2151	.2194
20500	.0040	.0025	.0038	.0066	.2149	.2194
41000	.0140	.0102	.0128	.0164	.2158	.2200
60000	.0212	.0195	.0213	.0269	.2167	.2206
80000	.0361	.0365	.0377	.0418	.2175	.2207
100000	.0581	.0608	.0599	.0667	.2131	.2198
112000	.0808	.0845	.0882	.1014	.2036	.2145
120000	.1080	.1135	.1171	.1328	.1868	.2032
130000	.1675	.1718	.1712	.1998	.1488	.1526
140000	.2395	.2432	.2344	.2751	.1095	.1082
150000	.3300	.2552	.3132	.3652	.0600	.0600
156000	.4298	.2565	.4118	.4694	.0017	.0000
158000	Maximum Load					

COLUMN 8161

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per		Lateral Deformation	
	100 ins.	1 in.	Total	Unit
57	.0000	.000000	.000000	.000000
181	.0042	.000042	.00001	.000001
362	.0134	.000134	-.000065	-.000005
530	.0222	.000222	-.000140	-.000012
706	.0380	.000380	-.000185	-.000015
883	.0614	.000614	.000080	.000007
990	.0887	.000887	.000820	.000068
1060	.1179	.001179	.002220	.000185
1150	.1775	.001775	.006660	.000554
1235	.2481	.002481	.010840	.000900
1325	.3216	.003216	.01578	.001310
1380	.4208	.004208	.02164	.001800
1395	Maximum			



Column 8161

Length 10'-0¼"

Area 113.1□"

Gauge length 100"

14 day test.

Reinf. #20 hoops.

Load 158000÷1395#□"

Cement Universal

Mixture 1-2-4

COLUMN 8171

Observed Data

Length 10 ft. 1 3/8 in.
Gauge Length 100 in.
Dimensions D. 3 ft. - 3¼ in.

Mixture 1-2-4.
Age when tested, 14 days.
Cement, Universal.

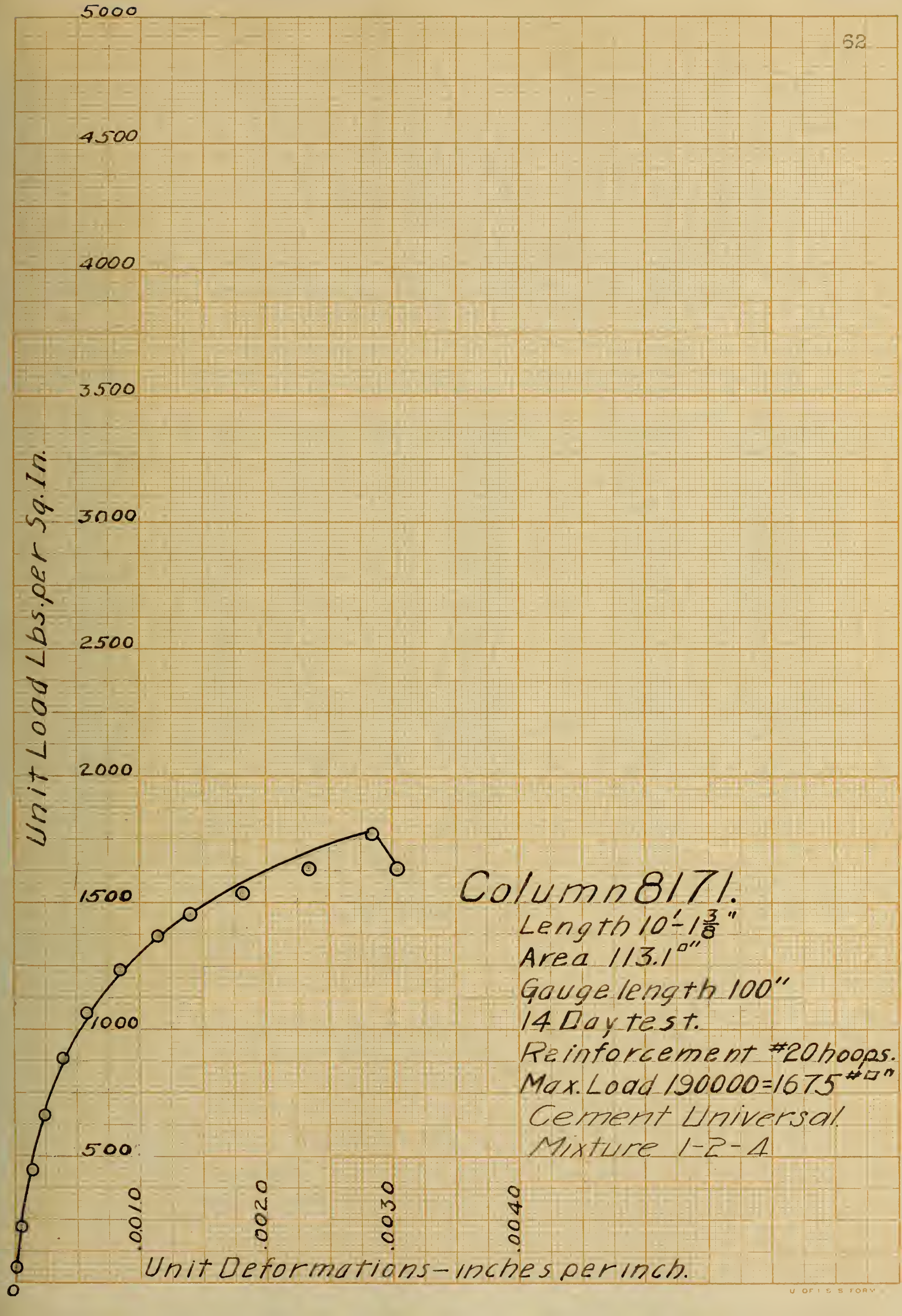
Reinforcements No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer Readings	
	N.E.	N.W.	S.W.	S.E.	E. W.	N. S.
6500	.0000	.0000	.0000	.0000	.88	-.90
25000	.0022	.0027	.0071	.0079	.96	-.16
50000	.0060	.0101	.0158	.0209	.99	-.20
75000	.0142	.0248	.0242	.0349	.97	-.26
100000	.0238	.0453	.0353	.0540	.87	-.28
120000	.0383	.0673	.0499	.0759	.67	-.19
140000	.0582	.0989	.0709	.1071	.16	.13
155000	.0863	.1314	.0985	.1395	.171	.160
165000	.1136	.1595	.1244	.1667	.062	.70
175000	.1545	.1982	.1669	.2069	.90	.160
185000	.2118	.2529	.2172	.2503	.26	.135
190000	.2472	.3063	.2788	.2978	.193	.97
185000	.2469	.3311	.3056	.3295	.080	.219

COLUMN 8171

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	1 in.
57	.00000	.000000
220	.00497	.000050
440	.01320	.000132
662	.02452	.000245
882	.03960	.000396
1060	.05785	.000579
1235	.08377	.000838
1370	.11392	.001139
1455	.14105	.001410
1540	.18162	.001862
1630	.23305	.002330
1675	.28252	.002825
1630	.30327	.003033



Column 8171.
Length 10'-1$\frac{3}{8}$"
Area 113.1$^{\square''}$
Gauge length 100"
14 Day test.
Reinforcement #20 hoops.
Max. Load 190000=1675$^{\#\square''}$
Cement Universal
Mixture 1-2-4

COLUMN 8183

Observed Data

Length 10 ft. 2 in.
Gauge Length 100 in.
Dimensions, Cir. 3 ft 5 in.

Mixture 1-2-4.
Age when tested,
Cement, Universal.

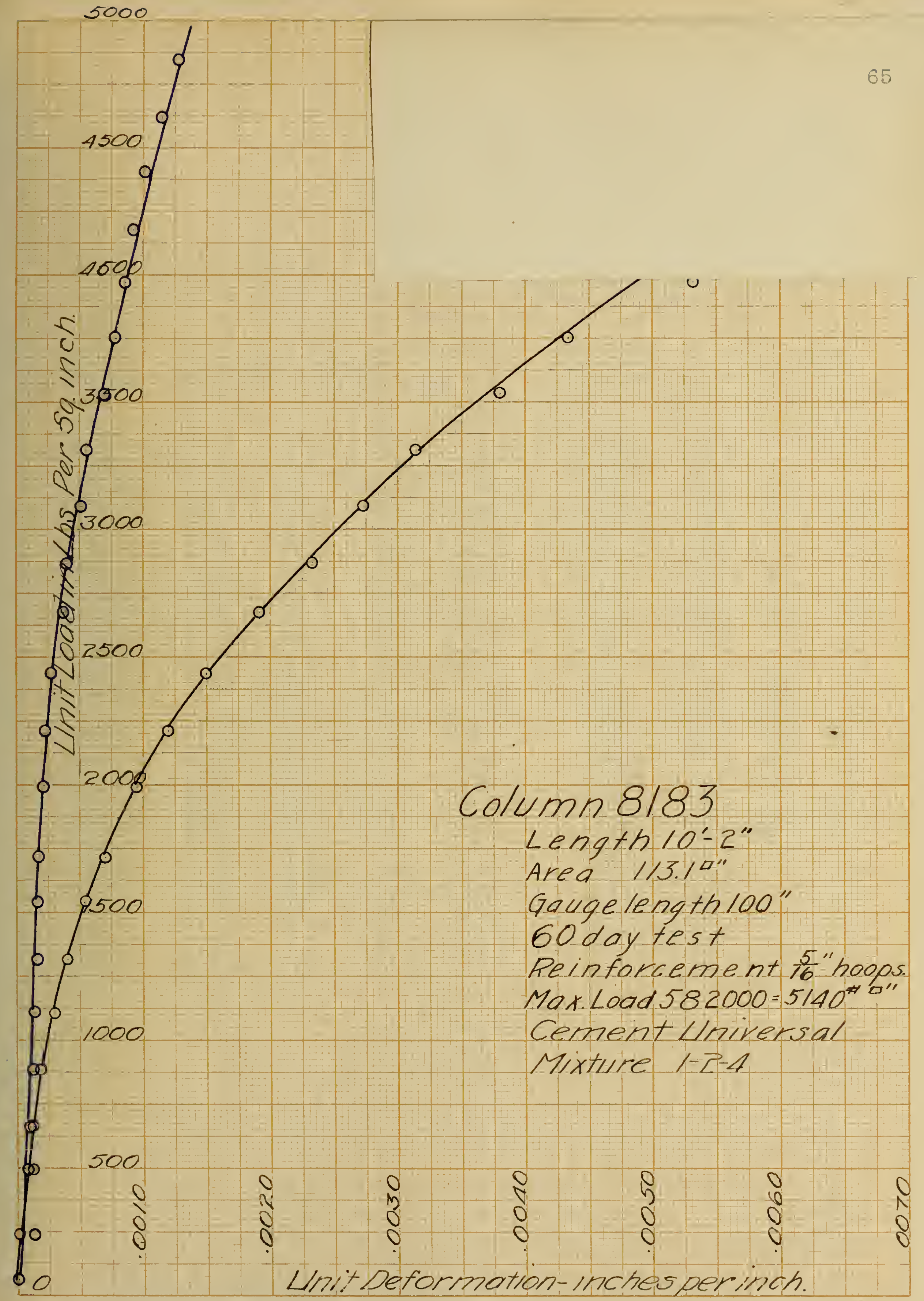
Reinforcements, No. 5/16 in. Hoops.

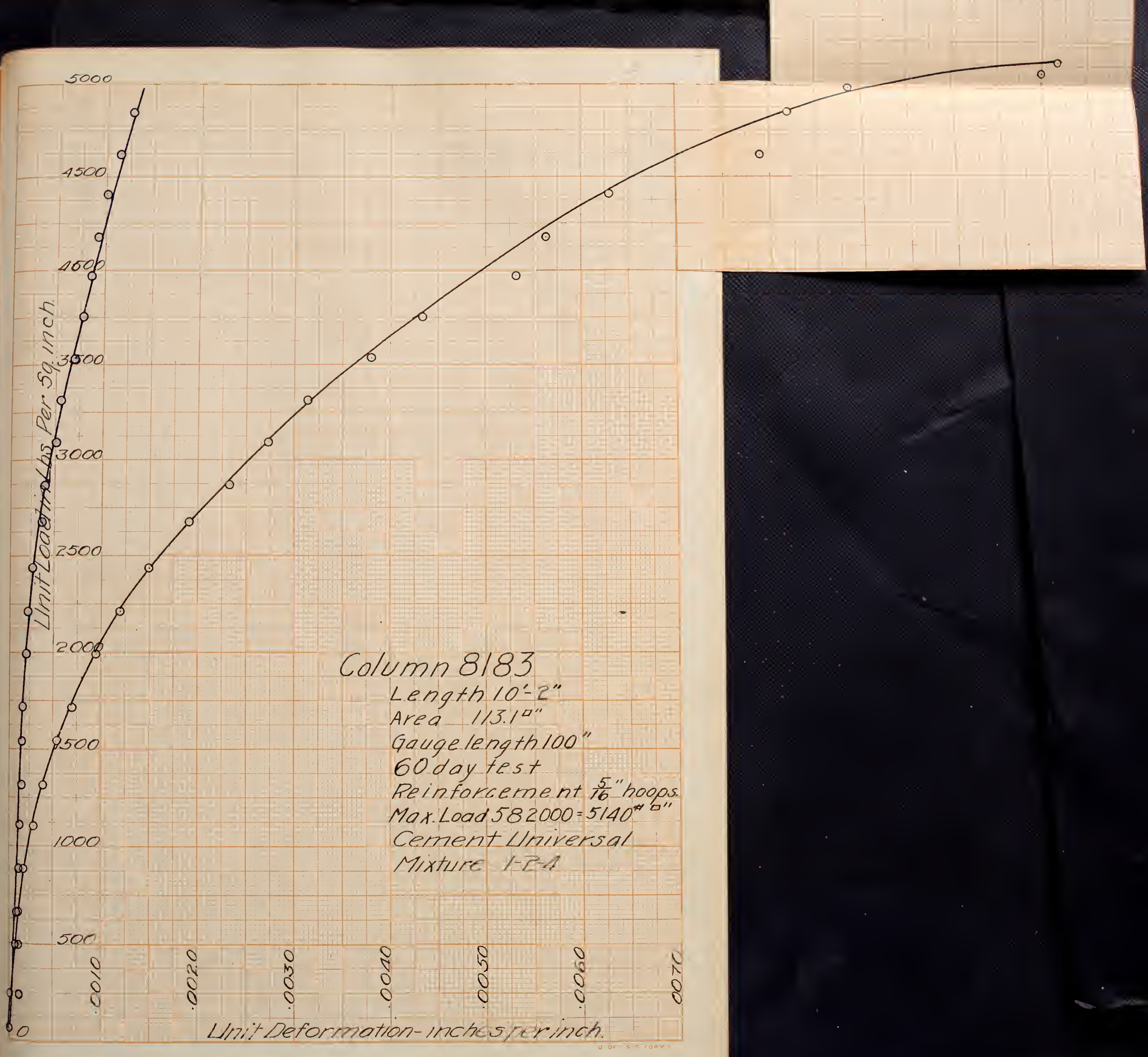
Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer Readings	
	S.E.	N.W.	S.W.	N.E.	E. W.	N. S.
6500	.0000	.0000	.0000	.0000	.2650	.1208
26500	.0028	.0050	.0031	.0040	.2396	.1150
55500	.0040	.0109	.0094	.0058	.2389	.1143
75000	.0040	.0160	.0171	.0058	.2381	.1146
100000	.0128	.0242	.0260	.0156	.2373	.1164
125000	.0218	.0330	.0353	.0262	.2360	.1157
150000	.0348	.0430	.0471	.0382	.2344	.1141
175000	.0505	.0561	.0619	.0532	.2326	.1133
200000	.0605	.0710	.0792	.0714	.2301	.1109
225000	.0950	.0907	.1018	.0942	.2270	.1072
250000	.1235	.1130	.1271	.1200	.2231	.1044
275000	.1606	.1309	.1624	.1548	.2169	.0990
300000	.2044	.1641	.2021	.1948	.2093	.0845
325000	.2564	.2057	.2493	.2318	.2004	.0872
350000	.3112	.2487	.3000	.2320	.1897	.0713
375000	.3710	.2926	.3580	.2354	.1790	.0581
400000	.4455	.3439	.4252	.3000	.1663	.0472
425000	.5200	.3630	.4911	.3632	.1554	.0388
450000	.6050	.4260	.5650	.4330	.1395	.0349
475000	.6994	.4295	.6144	.5105	.1258	.0323
500000	.7950	.4300	.7278	.5810	.1111	.0255
525000	.8650		.8440	.6600	.0889	.0147
550000	.8660		.9430	.6600	.0697	.9995
565000	.9100		1.0450	.7100	.	
575000	1.0600		1.1450			
582000	1.1200		1.2350			

COLUMN 8183

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total	Lateral Deformation Unit
57	.0000	.000000	.0000	.000000
234	.0037	.000037	.0156	.000127
490	.0075	.000075	.0163	.000132
662	.0107	.000107	.0166	.000135
882	.0196	.000196	.0160	.000130
1105	.0298	.000298	.0170	.000138
1320	.0408	.000408	.0186	.000151
1545	.0554	.000554	.0200	.000162
1715	.0703	.000703	.0224	.000182
1990	.0954	.000954	.0258	.000210
2210	.1209	.001209	.0292	.000237
2430	.1522	.001522	.0350	.000284
2650	.1913	.001913	.0460	.000374
2870	.2358	.002358	.0491	.000400
3090	.2729	.002729	.0624	.000507
3310	.3142	.003142	.0744	.000605
3530	.3786	.003786	.0862	.000700
3750	.4343	.004343	.0958	.000780
3970	.5322	.005322	.1057	.000858
4190	.5634	.005634	.1138	.000924
4410	.6334	.006334	.1246	.001010
4630	.7897	.007897	.1411	.001150
4850	.8200	.008200	.1583	.001290
4990	.8883	.008883		
5080	1.1o25	.011025		


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
.0010
.0020
.0030
.0040
.0050
.0060
.0070
Unit Load in Lbs. Per Sq. inch.
Unit Deformation - inches per inch.
Column 8183
Length 10'-2"
Area 113.1□"
Gauge length 100"
60 day test
Reinforcement $\frac{5}{16}$" hoops.
Max. Load 582000 = 5140# □"
Cement Universal
Mixture 1-2-4


Column 8183
Length 10'-2"
Area 113.1□"
Gauge length 100"
60 day test
Reinforcement 5/16" hoops.
Max. Load 582000 = 5140#□"
Cement Universal
Mixture 1-2-4
Unit Load in Lbs. Per Sq. inch.
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
.0010
.0020
.0030
.0040
.0050
.0060
.0070
Unit Deformation - inches per inch.

COLUMN 8184

Observed Data

Length 10 ft. $1\frac{1}{2}$ in.
Gauge Length 100 in.
Circumference 3 ft. 5 in.

Mixture 1-2-4.
Age when tested, 60 days.
Cement, Chicago A A.

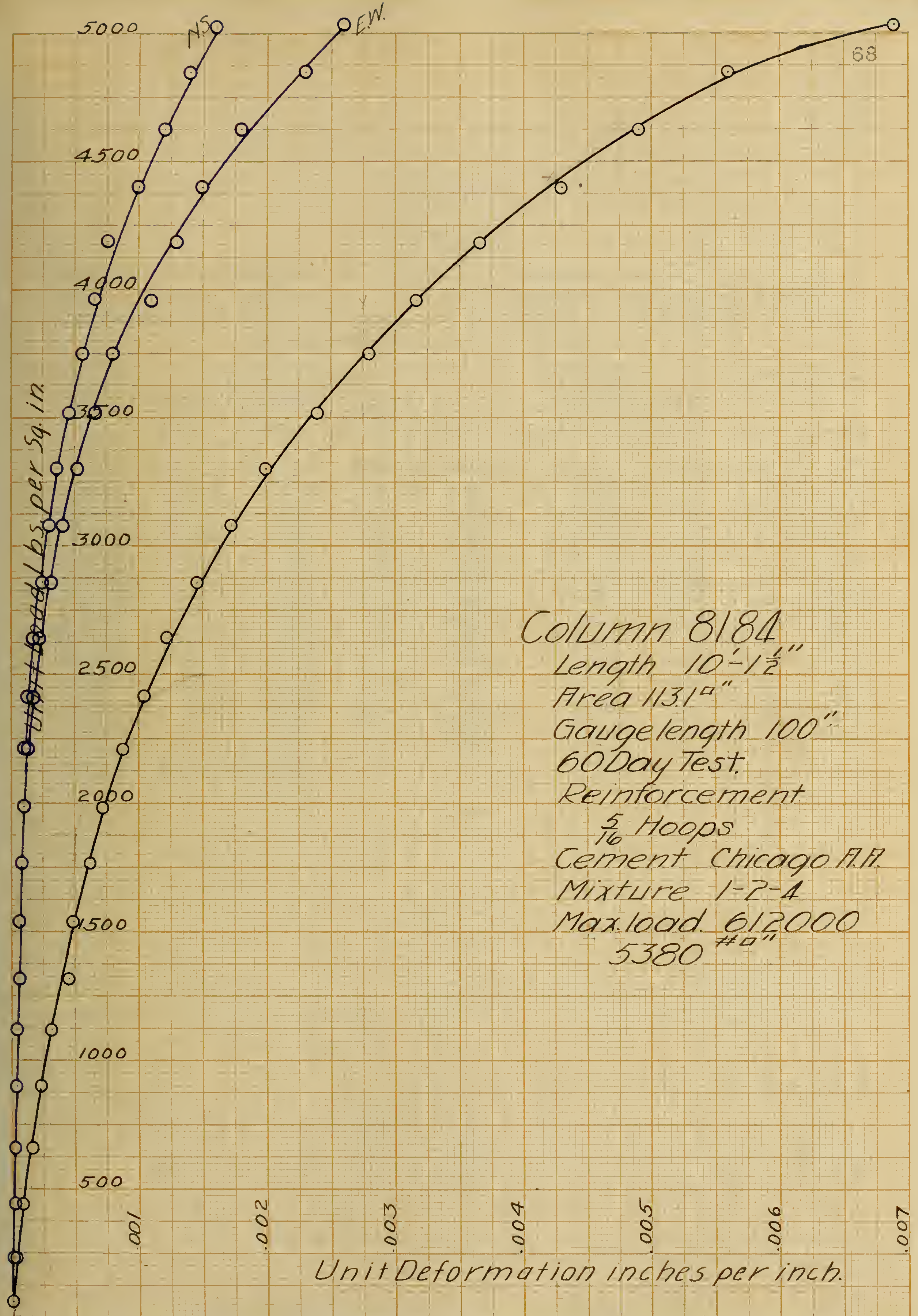
Reinforcement, 5/16 in. Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
7000	.0000	.0000	.0000	.0000	.2726	.2774	.00	.00
26000	.0020	.0040	.0012	.0017	.2721	.2763	.00	.00
50000	.0032	.0105	.0075	.0081	.2713	.2751	.00	.00
76000	.0208	.0182	.0134	.0148	.2707	.2736	.00	.00
102000	.0280	.0250	.0204	.0222	.2696	.2718	.00	.00
127000	.0350	.0330	.0285	.0302	.2680	.2704	.00	.00
150000	.0430	.0430	.0375	.0381	.2662	.2685	.00	.00
175000	.0498	.0544	.0438	.0453	.2651	.2672	.00	.00
201000	.0585	.0680	.0538	.0552	.2621	.2660	.00	.00
225000	.0675	.0810	.0635	.0632	.2593	.2647	.00	.00
251000	.0795	.0960	.0749	.0808	.2559	.2621	-.02	.03
275000	.0928	.1130	.0917	.0965	.2510	.2590	-.02	.04
300000	.1070	.1320	.1085	.1150	.2441	.2535	-.03	.06
325000	.1250	.1560	.1210	.1390	.2336	.2471	-.03	.07
350000	.1450	.1848	.1525	.1624	.2222	.2409	-.03	.07
375000	.1680	.2110	.1950	.1930	.2085	.2326	-.03	.10
400000	.1960	.2482	.2408	.2285	.1909	.2210	-.04	.11
425000	.2256	.2898	.2900	.2669	.1699	.2090	-.05	.13
450000	.2582	.3300	.3415	.3055	.1482	.1957	-.06	.17
475000	.2965	.3798	.4075	.3545	.1242	.1837	-.07	.19
500000	.3435	.4438	.4788	.4165	.0870	.1605	-.08	.23
525000	.3885	.5006	.5160	.4791	.0505	.1355	-.10	.28
550000	.4380	.5770	.5990	.5494	.9850	.1095	-.14	.33
575000	.4910	.6570	.7070	.7305	.2030	.2240	-.17	.42
600000	.5540	.7630	.8610	.7490	.1275	.1790	-.26	.60
612000	Maximum Load						-.42	1.23

COLUMN 8184

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation E. W.		N. S.		Deflection
	100 ins.	1 in.	Total	Unit	Total	Unit	
61.7	.0000	.000000	.00000	.000000	.00000	.000000	.00
229	.0029	.000029	.00005	.000004	.00011	.000009	.00
441	.0093	.000093	.00013	.000011	.00023	.000019	.00
662	.0165	.000165	.00019	.000015	.00038	.000031	.00
900	.0236	.000236	.00030	.000024	.00056	.000046	.00
1120	.0316	.000316	.00046	.000037	.00070	.000057	.00
1320	.0406	.000406	.00064	.000052	.00089	.000072	.00
1540	.0499	.000499	.00075	.000061	.00102	.000083	.00
1765	.0616	.000616	.00105	.000085	.00114	.000091	.00
1980	.0721	.000721	.00133	.000108	.00127	.000103	.03
2210	.0884	.000884	.00167	.000136	.00135	.000110	.036
2420	.1048	.001048	.00216	.000175	.00184	.000150	.045
2640	.1235	.001235	.00285	.000232	.00239	.000194	.066
2860	.1475	.001475	.00390	.000317	.00303	.000246	.077
3080	.1736	.001736	.00504	.000410	.00365	.000296	.077
3305	.2020	.002020	.00641	.000520	.00448	.000364	.105
3520	.2384	.002384	.00817	.000665	.00564	.000458	.117
3750	.2784	.002784	.01027	.000835	.00684	.000555	.14
3960	.3178	.003178	.01344	.001090	.00817	.000664	.18
4180	.3672	.003672	.01584	.001290	.00937	.000760	.204
4402	.4302	.004302	.01956	.001590	.01169	.000950	.245
4625	.4899	.004899	.02221	.001800	.01419	.001150	.30
4850	.5632	.005632	.02876	.002340	.01679	.001360	.36
5060	.6938	.006938	.03341	.002640	.02054	.001660	.452
5280	.7560	.007560	.03431	.002800	.03394	.002760	.654
5380	Maximum Load						1.234



Column 8184
Length 10'-1½"
Area 113.1□"
Gauge length 100"
60 Day Test.
Reinforcement
5/16 Hoops
Cement Chicago A.A.
Mixture 1-2-4
Max. load 612000
5380 #□"

COLUMN 8175

Observed Data

Length 10 ft. 0½ in.
Gauge Length 100 in.
Circumference 3 ft. 3½ in.

Mixture 1-2-4.
Age when tested, 60 days.
Cement, Universal.

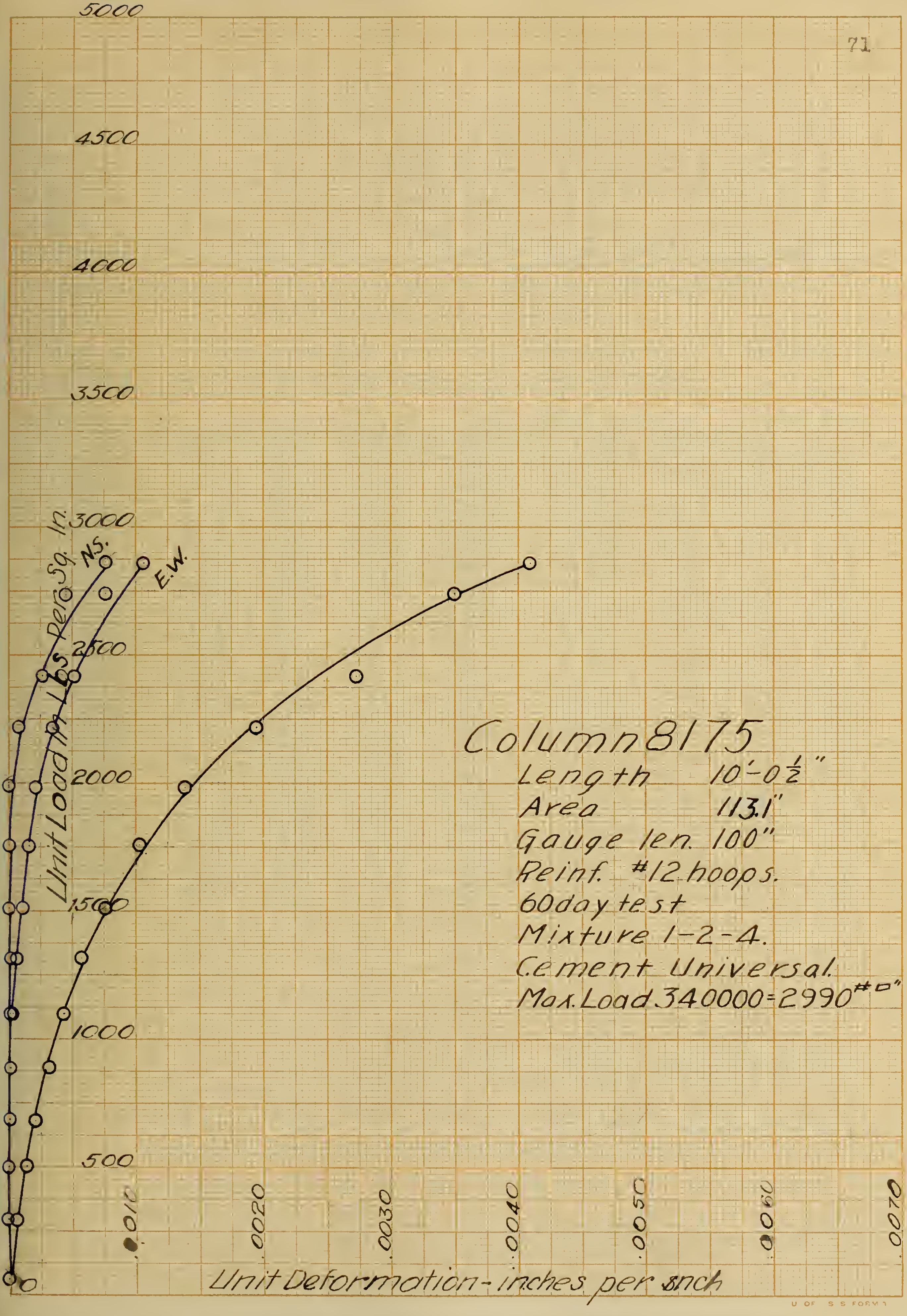
Reinforcement, No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2595	.2338	.00	.00
26000	.0061	.0039	.0046	.0061	.2629	.2588	.00	.00
57000	.0161	.0120	.0119	.0162	.2613	.2582	.00	.00
77000	.0230	.0182	.0195	.0237	.2600	.2575	.00	.00
101000	.0325	.0282	.0298	.0341	.2575	.2564	.00	.00
125000	.0438	.0395	.0408	.0462	.2550	.2551	.00	.00
150000	.0592	.0538	.0552	.0617	.2514	.2535	.00	.02
175000	.0792	.0719	.0735	.0816	.2466	.2518	.00	.02
200000	.1085	.0988	.0983	.1088	.2405	.2484	-.02	.04
225000	.1461	.1362	.1347	.1413	.2324	.2396	-.02	.04
250000	.2080	.1811	.1926	.1987	.2166	.2239	.02	.06
275000	.2851	.2600	.2702	.2765	.1965	.2019	.02	.06
300000	.3062	.3538	.3705	.3638	.1655	.1795	.02	.08
325000	.3062	.4701	.5040	.3751	.1288	.1415	.02	.14
340000	Maximum Load.							

COLUMN 8175

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation E. W. Total	Lateral Deformation E. W. Unit	Lateral Deformation N. S. Total	Lateral Deformation N. S. Unit	Deflection
57.4	.0000	.000000	.00000	.000000	.00000	.000000	.00
289	.0052	.000052	-.00034	-.000028	-.00250	-.000206	.00
502	.0141	.000141	-.00013	-.000011	-.00256	-.000212	.00
678	.0211	.000211	.00005	.000004	-.00237	-.000195	.00
892	.0312	.000312	.00020	.000017	-.00226	-.000187	.00
1100	.0426	.000426	.00045	.000037	-.00215	-.000178	.00
1320	.0575	.000575	.00081	.000067	-.00197	-.000163	.02
1540	.0766	.000766	.00129	.000107	-.00180	-.000149	.02
1760	.1036	.001036	.00190	.000157	-.00146	-.000121	.045
2220	.1951	.001951	.00429	.000354	.00099	.000816	.065
2420	.2730	.002730	.00630	.000520	.00319	.000264	.065
2740	.3508	.003508	.00940	.000777	.00543	.000448	.085
2860	.4139	.004139	.01300	.001074	.00923	.000763	.14
2990	Maximum Load						



Column 8175
Length 10'-0½"
Area 113.1"
Gauge len. 100"
Reinf. #12 hoops.
60 day test
Mixture 1-2-4.
Cement Universal.
Max. Load 340000=2990#□"

COLUMN 8176

Observed Data

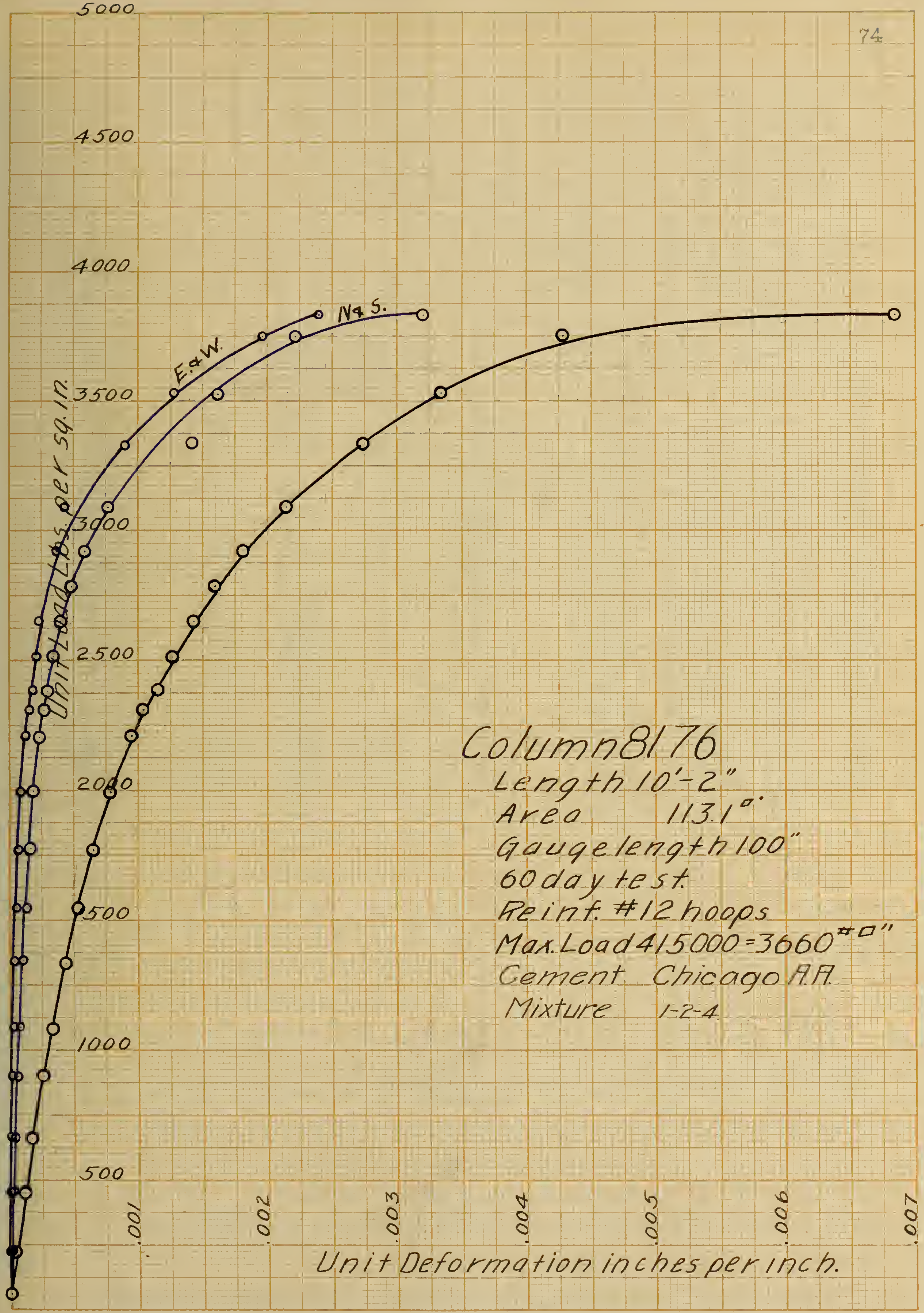
Length 10 ft. 2 in.
Gauge Length 100 in.
Circumference 3 ft. 3 3/8 in.
Mixture 1-2-4.
Age when tested, 60 days.
Cement, Chicago AA.
Reinforcement No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings N.W.	S.W.	S.E.	N.E.	Lateral Extensometer E. W.	N. S.	Deflection N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2401	.1863	.00	.00
25000	.0042	.0045	.0036	.0045	.2399	.1851	.02	..00
51000	.0106	.0093	.0104	.0120	.2387	.1839	.03	.00
75000	.0166	.0154	.0175	.0192	.2379	.1810	.03	.00
102000	.0255	.0240	.0261	.0279	.2364	.1775	.03	.00
123000	.0318	.0292	.0337	.0368	.2355	.1760	.03	.01
151000	.0418	.0388	.0444	.0476	.2333	.1726	.03	.01
175000	.0510	.0490	.0546	.0589	.2317	.1695	.03	.01
200000	.0618	.0578	.0671	.0732	.2284	.1669	.04	.02
226000	.0758	.0692	.0822	.0881	.2250	.1631	.04	.02
250000	.0910	.0842	.0993	.1072	.2207	.1575	.04	.03
261000	.1000	.0925	.1092	.1171	.2179	.1542	.05	.03
271000	.1098	.1000	.1194	.1286	.2150	.1494	.05	.03
284000	.1210	.1108	.1328	.1426	.2108	.1447	.05	.05
300000	.1360	.1245	.1496	.1609	.2030	.1373	.06	.06
315000	.1538	.1400	.1692	.1814	.1970	.1270	.07	.07
330000	.1718	.1570	.1908	.2043	.1862	.1150	.07	.08
350000	.2050	.1860	.2282	.2433	.1695	.0922	.08	.09
377000	.2598	.2362	.2922	.3101	.1305	.0143	.12	.11
400000	.3158	.2756	.3624	.3839	.0848	.9010	.18	.15
425000	.4155	.3120	.4777	.5088	.1870	.1120	.30	.23
434000	.5988	.8530	.6210	.6690	.0780	.8950	.50	.54
415000	.6180	.9130	.8507	.8747			.70	.92

COLUMN 8176

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation				Deflection
			E. W.		N. S.		
	100 ins.	1 in.	Total	Unit.	Total	Unit	
57.4	.0000	.000000	.000000	.000000	.00000	.000000	.00
222	.0042	.000042	.000020	.000002	.00016	.000013	.02
451	.0105	.000105	.000140	.000012	.00024	.000020	.03
662	.0173	.000173	.000210	.000017	.00053	.000044	.03
900	.0260	.000260	.000370	.000031	.00088	.000073	.03
1085	.0330	.000330	.000460	.000038	.00103	.000085	.032
1335	.0433	.000433	.000680	.000056	.00137	.000113	.032
1545	.0535	.000535	.000840	.000069	.00168	.000139	.032
1765	.0650	.000650	.001170	.000097	.00194	.000160	.045
1995	.0788	.000788	.001510	.000125	.00232	.000192	.045
2210	.0953	.000953	.001940	.000160	.00288	.000238	.05
2310	.1048	.001048	.002220	.000183	.00321	.000265	.058
2390	.1145	.001145	.002510	.000207	.00360	.000305	.058
2510	.1270	.001270	.002970	.000245	.00416	.000344	.07
2650	.1430	.001430	.003510	.000290	.00490	.000405	.086
2780	.1610	.001610	.004340	.000358	.00593	.000490	.10
2920	.1810	.001810	.005390	.000445	.00713	.000591	.105
3090	.2155	.002155	.007060	.000584	.00941	.000777	.12
3330	.2745	.002745	.010960	.000905	.01720	.001420	.164
3530	.3345	.003345	.015530	.001280	.01953	.001614	.236
3750	.4288	.004288	.023830	.001970	.02793	.002250	.38
3830	.6855	.006855	.024730	.002040	.04023	.003320	.735
3660	.8140	.008140					1.175



Column 8176
Length 10'-2"
Area 113.1□"
Gauge length 100"
60 day test.
Reinf. #12 hoops
Max. Load 415000 = 3660#□"
Cement Chicago A.A.
Mixture 1-2-4

COLUMN 8251

Observed Data

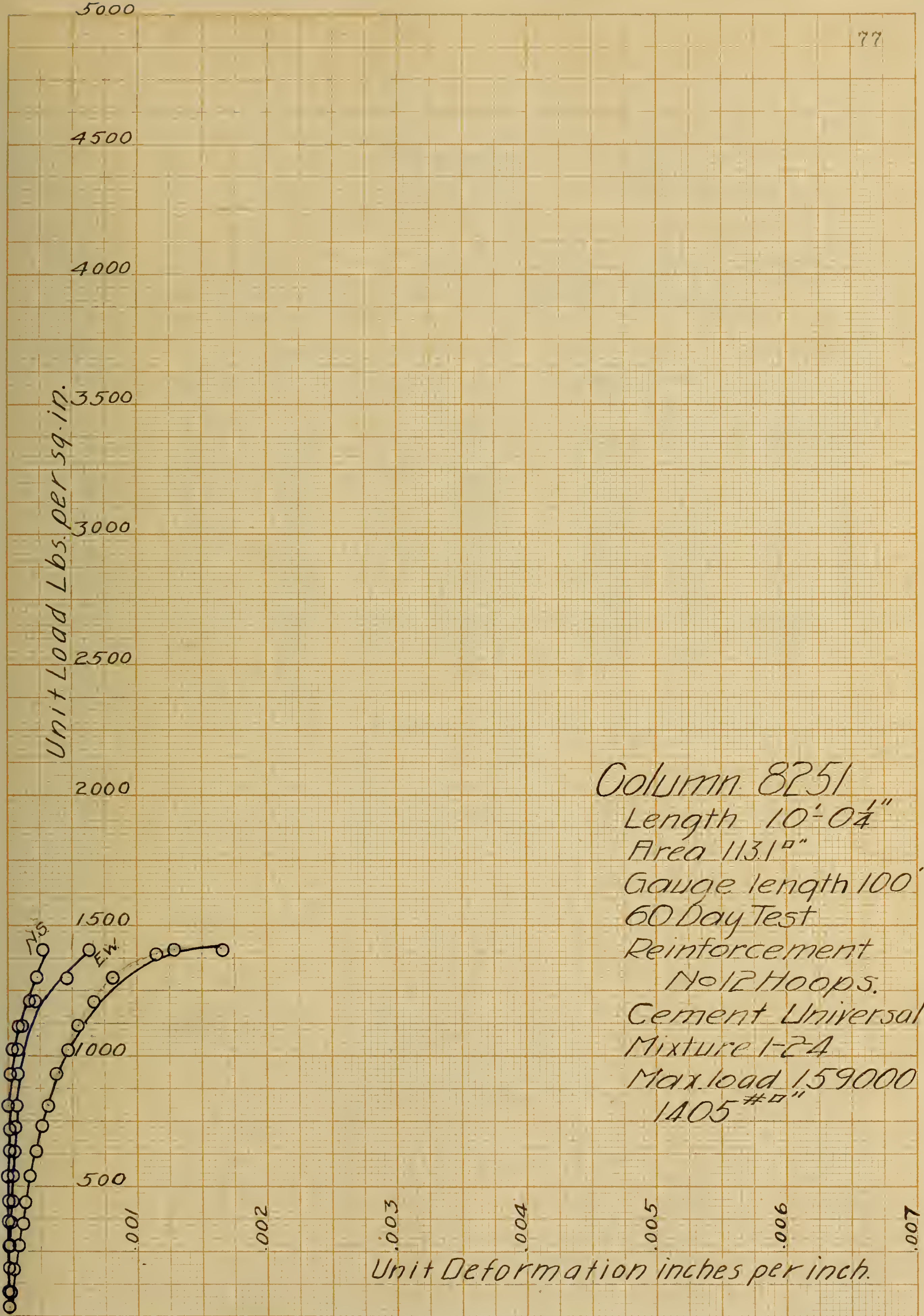
Length 10 ft. 0¼ in.	Mixture 1-2-4.
Gauge Length 100 in.	Age when tested, 60 days.
Circumference 3 ft. 3¾ in.	Cement, Universal.
Reinforcement, No. 12 Hoops.	Eccentricity, 1¼ in.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
4000	.0000	.0000	.0000	.0000	..2562	.2718	.00	-.04
10800	.0004	.0000	.0020	.0025	.2558	.2707	.00	-.04
20700	.0014	.0006	.0058	.0084	.2560	.2699	.00	-.04
31000	.0024	.0012	.0115	.0140	.2590	.2584	.02	-.04
40500	.0024	.0016	.0167	.0195	.2589	.2486	.02	-.02
50500	.0024	.0023	.0231	.0252	.2591	.2476	.02	-.01
61000	.0022	.0032	.0311	.0326	.2591	.2470	.06	.00
72000	.0021	.0044	.0401	.0409	.2590	.2462	.08	.02
83000	.0014	.0052	.0497	.0497	.2589	.2457	.08	.04
92000	.0004	.0060	.0605	.0596	.2587	.2450	.10	.06
105000	-.0014	.0068	.0750	.0726	.2584	.2433	.12	.08
116000	-.0035	.0070	.0940	.0900	.2577	.2421	.16	.10
127000	-.0068	.0071	.1140	.1083	.2569	.2410	.20	.14
137000	-.0135	.0058	.1440	.1344	.2540	.2391	.24	.18
147000	-.0246	.0024	.1815	.1671	.2507	.2367	.30	.24
157000	-.0732	-.0194	.2897	.2640	.2326	.2305	.54	.50
159000	-.2006	-.0882	.4510	.3971	.2030	.2220	.98	.98
159000	-.2352	-.0966	.5270	.4690	.1805	.2175	1.10	1.14

COLUMN 8251

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation				Deflection
	100 ins.	1 in.	Total		Unit		
			E. W.	N. S.	E. W.	N.S.	
35	.0000	.000000	.00000	.00000	.000000	.000000	.00
95	.0012	.000012	.00004	.00011	.000003	.000009	.00
183	.0040	.000040	.00002	.00019	.000002	.000016	.00
274	.0075	.000075	-.00008	.00025	-.000007	.000021	.02
358	.0101	.000101	-.00007	.00023	-.000006	.000019	.028
446	.0132	.000132	-.00009	.00033	-.000008	.000027	.036
540	.0175	.000175	-.00009	.00039	-.000008	.000032	.06
636	.0219	.000219	-.00008	.00047	-.000007	.000039	.083
734	.0265	.000265	-.00007	.00052	-.000006	.000043	.08
813	.0316	.000316	-.00005	.00059	-.000004	.000049	.103
927	.0382	.000382	-.00002	.00076	-.000002	.000063	.127
1025	.0469	.000469	.00009	.00088	.000008	.000073	.173
1120	.0556	.000556	.00017	.00099	.000014	.000082	.23
1210	.0677	.000677	.00046	.00118	.000038	.000098	.28
1300	.0816	.000816	.00079	.00142	.000065	.000117	.363
1390	.1151	.001151	.00260	.00204	.000215	.000168	.710
1405	.1298	.001298	.00556	.00289	.000460	.000240	1.36
1405	.1660	.001660	.00781	.00334	.000645	.000276	1.56



Column 8251
Length 10'-0¼"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement
No12 Hoops.
Cement Universal
Mixture 1-2-4
Max load 159000
1405 #□"

COLUMN 8252

Observed Data

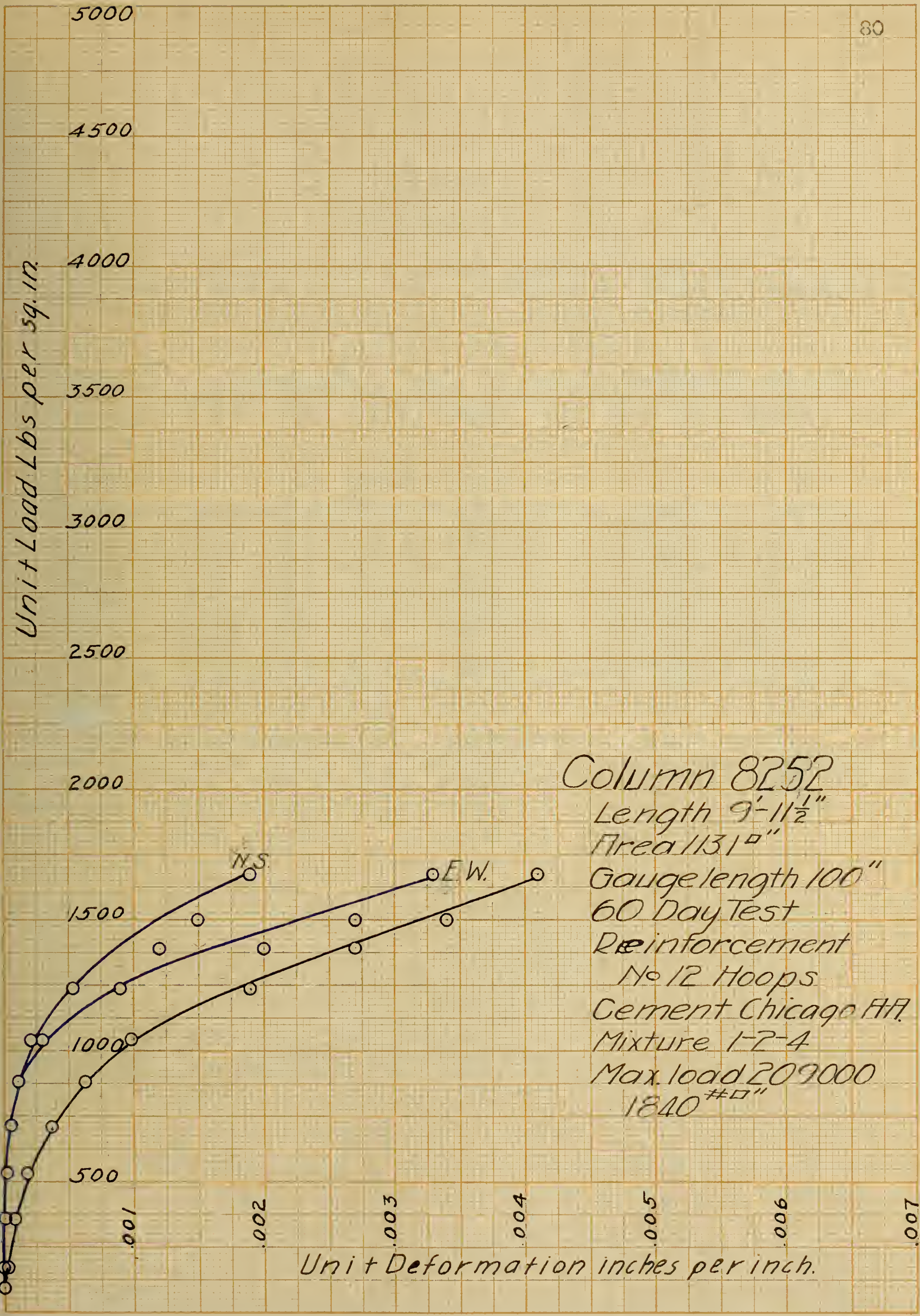
Length 9 ft. 11½ in.	Mixture 1-2-4.
Gauge Length 100 in.	Age when tested, 60 days.
Circumference 3 ft. 3½ in.	Cement, Chicago AA.
Reinforcement No. 12 Hoops.	Eccentricity, 1¼ in.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
11000	.0000	.0000	.0000	.0000	.2525	.2740	.22	-.28
20000	.0000	.0046	.0056	.0010	.2515	.2747	.22	-.28
40000	-.0033	.0147	.0227	.0030	.2510	.2743	.20	-.22
60000	-.0071	.0293	.0482	.0091	.2496	.2720	.18	-.20
80000	-.0130	.0490	.0855	.0250	.2469	.2674	.18	-.14
100000	-.0180	.0655	.1382	.0585	.2378	.2603	.18	-.06
118000	-.0271	.0782	.2150	.1200	.2172	.2473	.24	.10
140000	-.0700	.0795	.4200	.3005	.1435	.2083	.42	.52
158000	-.1470	.0685	.7295	.4910	.9985	.1345	.80	1.14
170000	-.1605	.0720	.8710	.6069	.2030	.2300	.42	.38
190000	-.1340	.1102	.9930	.7110	.1312	.1810	.52	.50
209000	Maximum Load						.56	.64

COLUMN 8252

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation				Deflection
			Total		Unit		
	100 ins.	1 in.	E. W.	N. S.	E. W.	N. S.	
92	.0000	.000000	.00000	.00000	.000000	.000000	.00
172	.0028	.000028	.00010	-.00007	.000008	-.000006	.00
353	.0089	.000089	.00015	-.00003	.000012	-.000002	.065
530	.0192	.000192	.00029	.00020	.000024	.000016	.09
707	.0370	.000370	.00056	.00066	.000045	.000056	.146
883	.0620	.000620	.00147	.00137	.000121	.000113	.224
1040	.0991	.000991	.00353	.00267	.000292	.000220	.182
1235	.1900	.001900	.01090	.00657	.000900	.000543	.315
1395	.2798	.002798	.02540	.01395	.002020	.001150	1.01
1500	.3395	.003395	.03258	.01788	.002700	.001475	1.30
1675	.4106	.004106	.03966	.02275	.003280	.001880	1.454
1840	Maximum Load.						



Column 8252
Length 9'-11½"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement
No 12 Hoops
Cement Chicago A.A.
Mixture 1-2-4
Max. load 209000
1840 #□"

COLUMN 8173

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Dimensions Cir. 3 ft 3¼ in.

Mixture 1-2-4.
Age when tested, 60 days.
Cement, Universal.

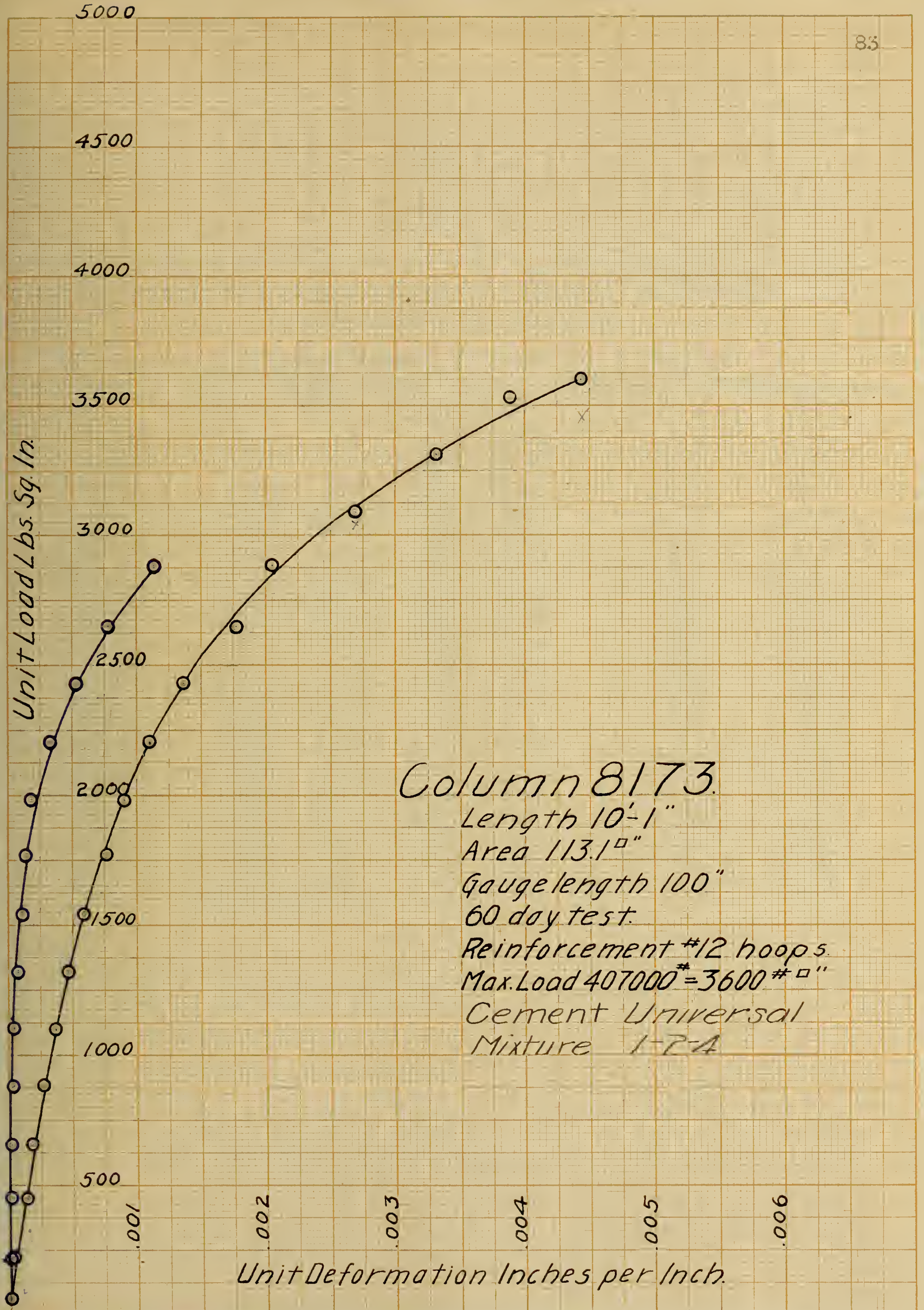
Reinforcements No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer Readings	
	N.E.	N.W.	S.W.	S.E.	E. W.	N. S.
6500	.0000	.0000	.0000	.0000	.2093	.1413
25000	.0035	.0049	.0034	.0052	.2089	.1409
51000	.0114	.0120	.0103	.0124	.2079	.1405
75000	.0178	.0192	.0171	.0200	.2069	.1394
100000	.0268	.0275	.0260	.0284	.2059	.1366
125000	.0356	.0362	.0350	.0375	.2045	.1360
150000	.0462	.0474	.0465	.0484	.2026	.1347
175000	.0570	.0600	.0589	.0596	.2003	.1303
201000	.0720	.0747	.0725	.0754	.1969	.1268
225000	.0900	.0909	.0897	.0915	.1914	.1247
250000	.1122	.1118	.1065	.1098	.1890	.1167
275000	.1353	.1430	.1381	.1310	.1689	.1036
300000	.1593	.1881	.1842	.1734	.1393	.0815
325000	.1621	.1932	.2399	.2234	.1057	.0550
350000	.1635	.3078	.3150	.2915	.0628	.0154
375000	.1633	.4010	.3992	.3684	.0065	-.8065
400000	.1647	.4550	.4530	.4802		
407000	.1663	.4600	.4800	.6720		

COLUMN 8173

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per		Transverse Deformation	
	100 ins.	1 in.	Total	Unit
57.4	.00000	.000000	.00000	.000000
221	.00425	.0000425	.00000	.000000
450	.01402	.0001402	.00004	.000003
663	.01852	.0001852	.00011	.000009
883	.02717	.0002717	.00022	.000017
1102	.03607	.0003607	.00041	.000034
1320	.04707	.0004707	.00051	.000042
1545	.05887	.0005887	.00065	.000054
1770	.07460	.0007640	.00100	.000083
1980	.09052	.0009052	.001345	.000111
2208	.11007	.0011007	.001725	.000142
2430	.13685	.0013685	.002245	.000185
2650	.17670	.0017670	.003955	.000326
2880	.20465	.0020465	.00649	.000536
3090	.26945	.0026945	.009495	.000783
3310	.33297	.0033297	.01362	.001126
3530	.38822	.0038822		
3600	.44457	.0044457		



Column 8173.
Length 10'-1"
Area 113.1□"
Gauge length 100"
60 day test.
Reinforcement #12 hoops.
Max. Load 407000# = 3600 #□"
Cement Universal
Mixture 1-2-4

COLUMN 8174

Observed Data

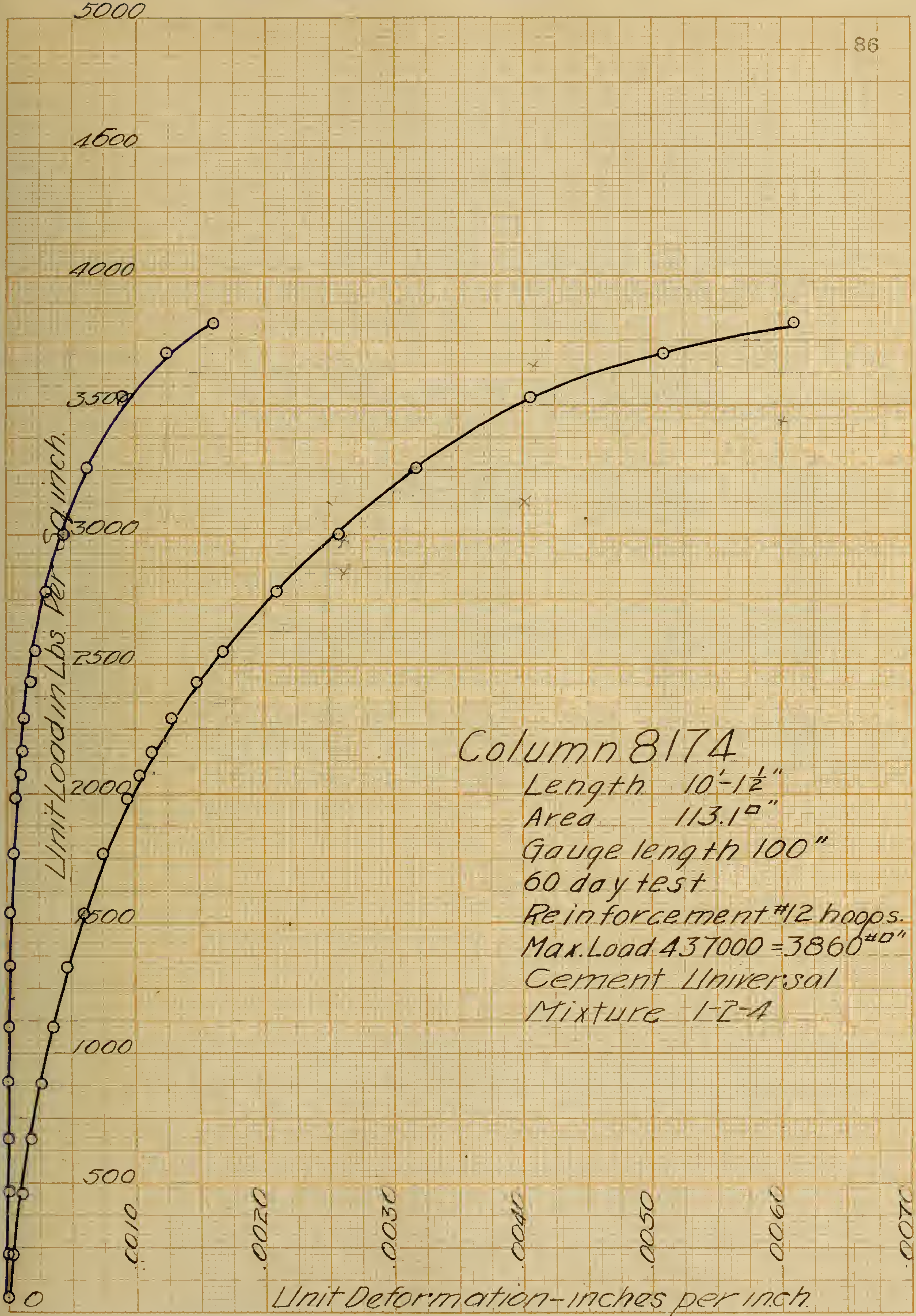
Length 10 ft. 1½ in. Mixture 1-2-4.
Gauge Length 100 ins. Age when tested, 60 days.
Dimensions, Cir.3 ft 3 3/8 in. Cement, Universal.
Reinforcement, No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer Readings	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.
6500	.0000	.0000	.0000	.0000	.2760	.2457
26500	.0038	.0015	.0023	.0070	.2768	.2458
52000	.0118	.0078	.0089	.0141	.2763	.2456
76000	.0172	.0179	.0207	.0190	.2759	.2456
100000	.0261	.0270	.0159	.0258	.2748	.2449
125000	.0348	.0365	.0194	.0359	.2734	.2435
151000	.0438	.0480	.0303	.0460	.2713	.2426
175000	.0562	.0610	.0428	.0594	.2692	.2394
201000	.0720	.0768	.0584	.0742	.2660	.2365
225000	.0912	.0961	.0769	.0928	.2617	.2328
235000	.1012	.1065	.0863	.1021	.2595	.2312
245000	.1105	.1158	.0950	.1114	.2578	.2288
260000	.1252	.1308	.1090	.1263	.2517	.2248
275000	.1450	.1505	.1271	.1454	.2455	.2193
290000	.1670	.1718	.1470	.1668	.2357	.2116
315000	.2090	.2138	.1882	.2078	.2170	.1950
340000	.2585	.2615	.2274	.2542	.1930	.1745
370000	.3295	.3125	.2960	.3226	.1575	.1444
400000	.4195	.4040	.3814	.4092	.1140	.1045
420000	.5250	.5050	.4824	.5152	.0690	.0630
433000	.5410	.6100	.5940	.6200	.2715	.2690
437000	Maximum Load					

COLUMN 8174

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total	Lateral Deformation Unit
37.4	.000000	.000000	.00000	.000000
224.0	.0037	.000037	.000045	.000004
460	.0107	.000107	.000020	.000002
670	.0187	.000187	.000010	.000001
889	.0264	.000264	.000100	.000008
1102	.0362	.000362	.000240	.000020
1330	.0470	.000470	.000390	.000032
1540	.0602	.000602	.000655	.000054
1770	.0755	.000755	.000960	.000079
1980	.0945	.000945	.001360	.000112
2070	.1043	.001043	.001550	.000128
2160	.1136	.001136	.001755	.000145
2290	.1286	.001286	.002260	.000187
2430	.1480	.001480	.002840	.000234
2550	.1693	.001693	.003730	.000308
2780	.2108	.002108	.005185	.000453
3000	.2579	.002579	.007610	.000650
3260	.3172	.003172	.011040	.000908
3530	.4066	.004066	.015160	.001250
3700	.5101	.005101	.019485	.001610
3820	.6150	.006150	.023310	.001925
3860	Maximum Load.			



Column 8174
Length 10'-1½"
Area 113.1□"
Gauge length 100"
60 day test
Reinforcement #12 hoops.
Max. Load 437000 = 3860#□"
Cement Universal
Mixture 1-2-4

COLUMN 8163

Observed Data

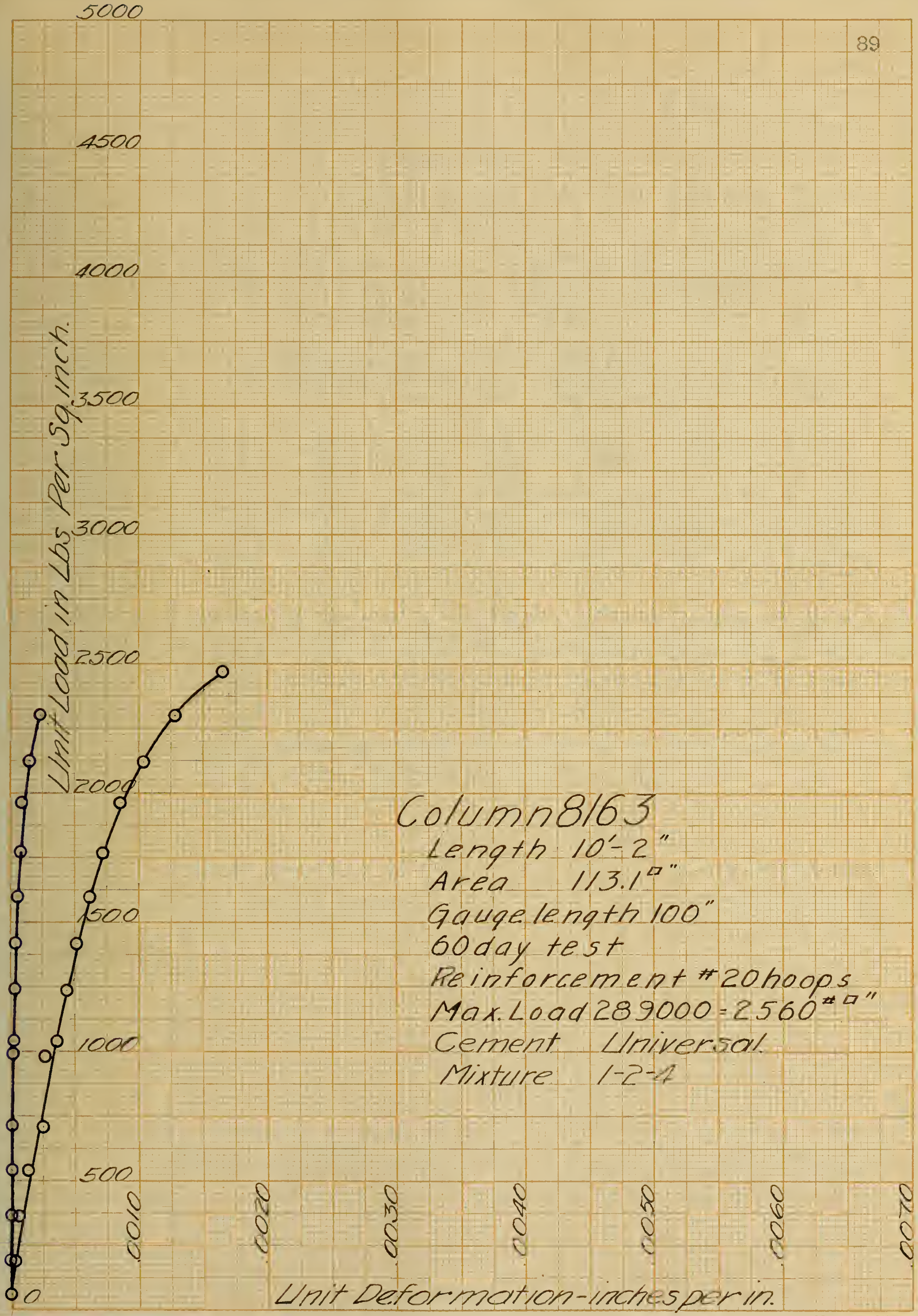
Length 10 ft. 2 in. Mixture 1-2-4.
Gauge Length 100 ins. Age when tested, 60 days.
Dimensions, Cir. 3 ft. 3¼ in. Cement, Universal.
Reinforcement, No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer Readings	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.
6500	.0000	.0000	.0000	.0000	.1690	.2604
21000	..0032	.0020	.0036	.0032	.1689	.2600
41000	.0076	.0070	.0100	.0082	.1686	.2593
61000	.0132	.0134	.0166	.0140	.1678	.2586
80000	.0191	.0205	.0234	.0196	.1673	.2577
102000	.0272	.0283	.0262	.0280	.1665	.2568
118000	.0352	.0346	.0376	.0356	.1660	.2559
140000	.0442	.0424	.0456	.0442	.1649	.2546
161000	.0541	.0510	.0552	.0510	.1640	.2529
181000	.0608	.0608	.0658		.1630	.2510
202000	.0740	.0730	.0806	.0623	.1613	.2489
222000	.0870	.0860	.0952	.0782	.1596	.2461
240000	.1005	.1021	.1150	.0970	.1573	.2466
261000	.1284	.1285	.1495	.1074	.1507	.2355
280000	.1745	.1719	.1822	.1374	.1400	.2215
289000	Maximum Load.					

COLUMN 8163.

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total	Lateral Deformation Unit
57.4	.000000	.000000	.00000	.000000
185	.00300	.000030	.00001	.000001
362	.00595	.0000595	.00004	.000003
538	.01430	.000143	.00012	.000010
706	.02565	.0002565	.00017	.000014
986	.02740	.0002740	.00025	.000021
1040	.03575	.0003575	.00030	.000025
1234	.04410	.0004410	.00041	.000034
1420	.05280	.0005280	.00050	.000042
1599	.0625	.0006250	.00060	.000050
1770	.0725	.000725	.00077	.000064
1960	.0866	.000866	.00096	.000080
2120	.10365	.0010365	.00117	.000097
2300	.12845	.0012845	.00183	.000152
2470	.16650	.001665	.00290	.000240
2560	Maximum Load			



Column 8163
Length 10'-2"
Area 113.1□"
Gauge length 100"
60 day test
Reinforcement #20 hoops
Max. Load 289000 = 2560 #□"
Cement Universal.
Mixture 1-2-4

COLUMN 8164

Observed Data

Length 10 ft. 1 in.
Gauge Length 100 in.
Circumference 3 ft. 2$\frac{3}{4}$ in.

Mixture 1-2-4.
Age when tested, 60 days.
Cement, Universal.

Reinforcement, No. 20 Hoops.

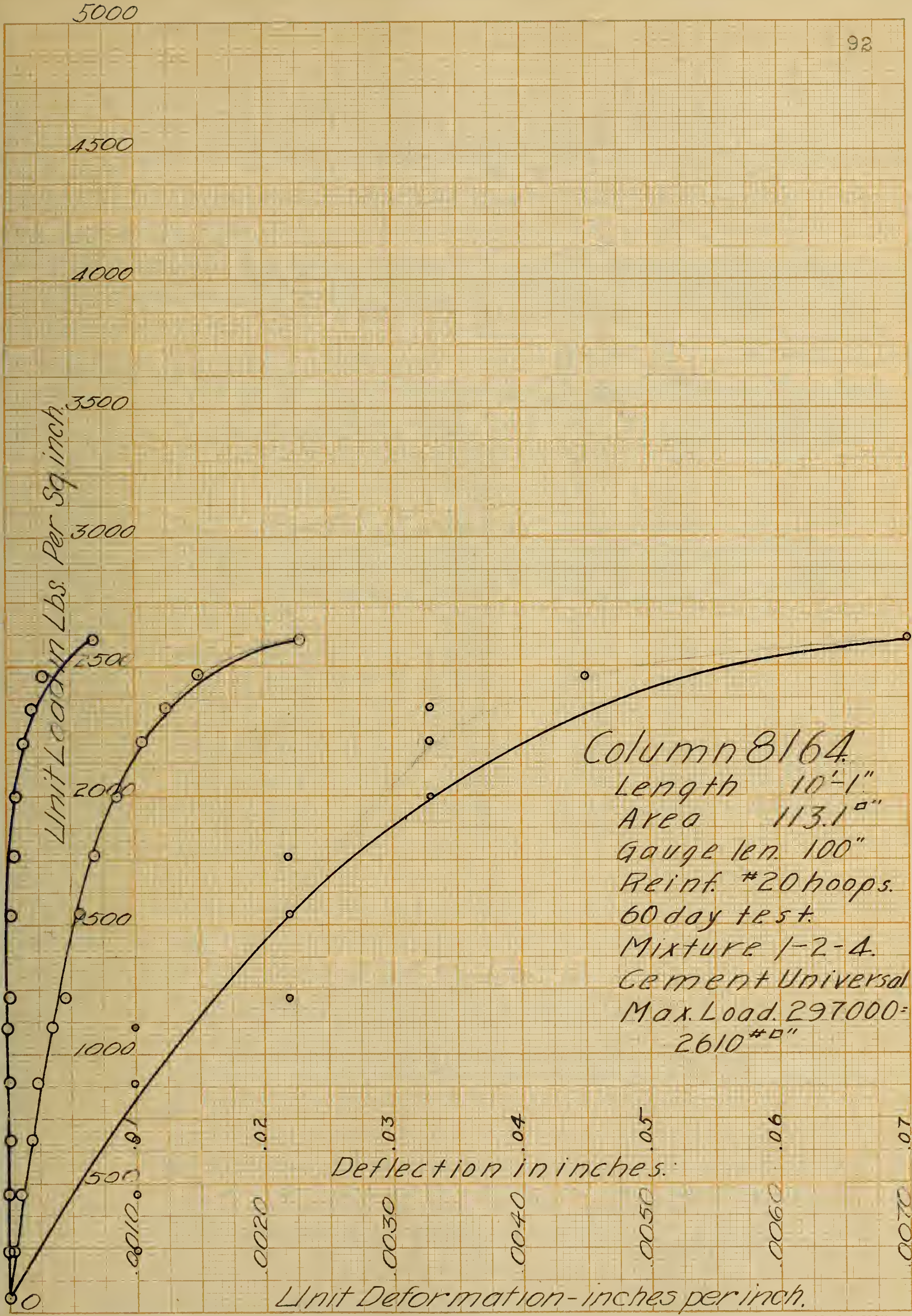
Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2476	.2432	3.78	.54
27000	.0045	.0050	.0047	.0051	.2468	.2419	3.77	.54
51500	.0115	.0125	.0062	.0112	.2455	.2429	3.77	.54
76000	.0186	.0211	.0197	.0178	.2435	.2429	3.77	.54
101000	.0255	.0265	.0234	.0229	.2420	.2437	3.77	.54
125000	.0348	.0418	.0368	.0304	.2417	.2437	3.77	.54
150500	.0462	.0520	.0456	.0410	.2390	.2434	3.76	.56
175000	.0582	.0640	.0551	.0517	.2371	.2428	3.76	.56
200000	.0712	.0765	.0667	.0634	.2332	.2420	3.76	.56
227000	.0892	.0920	.0834	.0795	,2261	.2399	3.75	.56
250000	.1085	.1168	.1016	.0958	.2187	.2364	3.75	.56
265000	.1260	.1360	.1170	.1098	.2107	.2310	3.75	.56
280000	.1505	.1635	.1392	.1292	.1975	.2197	3.74	.56
297000	.2460	.2670	.2250	.1946	.1475	.1790	3.71	.54

Load dropped off to 270000.
Several hoops failed.

COLUMN 8164

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per		Lateral Deformation		Deflection
	100 ins.	1 in.	Total	Unit	Inches
57	.0000	.000000	.000000	..000000	.00
238	.0048	.000048	.000105	.000001	.01
455	.01035	.000104	.000120	.000010	.01
670	.01920	.000192	.000220	.000018	.01
890	.02457	.000246	.000255	.000021	.01
1105	.03595	.000360	.000270	.000022	.01
1320	.04620	.000462	.000420	.000035	.022
1545	.0575	.000575	.000545	.000045	.022
1770	.06945	.000694	.000780	.000065	.022
2000	.08602	.000860	.000900	.000075	.033
2210	.10568	.001057	.001775	.000148	.033
2340	.12470	.001247	.002455	.000204	.033
2470	.15060	.001506	.003680	.000297	.045
2610	.23315	.002332	.008215	.000685	.070



Column 8164.
Length 10'-1"
Area 113.1□"
Gauge len. 100"
Reinf. #20 hoops.
60 day test.
Mixture 1-2-4.
Cement Universal
Max. Load. 297000 =
2610#□"

COLUMN 8231

Observed Data

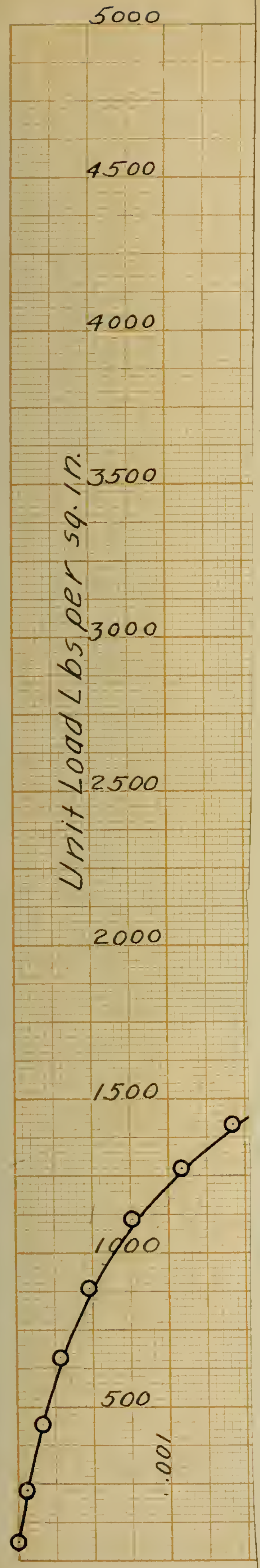
Length 9 ft. 10½ in. Mixture 1-3-6.
Gauge Length 100 in. Age when tested, 60 days.
Circumference 3 ft. 4¼ in. Cement, Universal.
Reinforcement 5/16 in. Hoops.

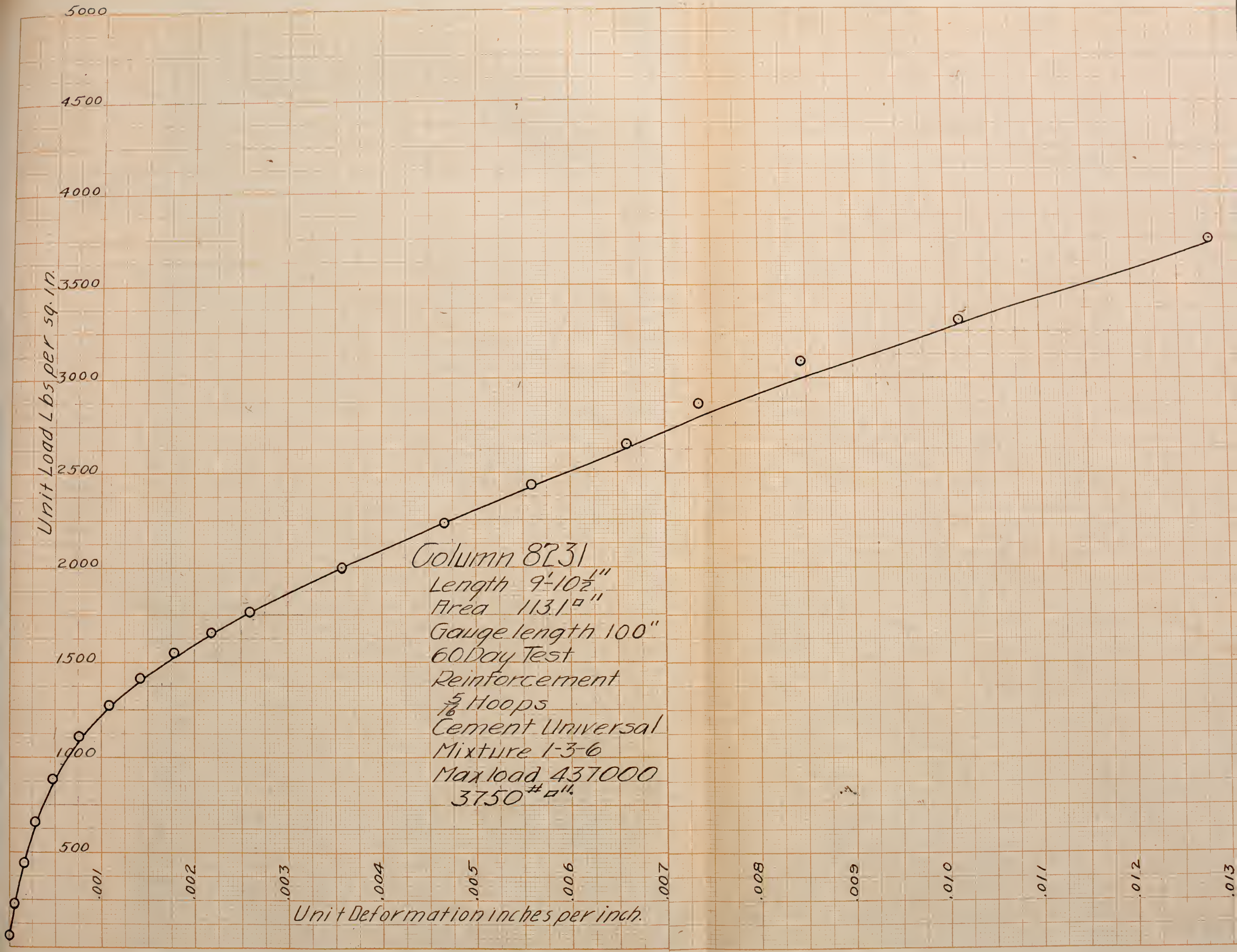
Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2605	.2228	.00	.00
26000	.0068	.0046	.0061	.0074	.2610	.2221	.00	.00
50000	.0166	.0132	.0157	.0183	.2617	.2214	.00	.00
75000	.0282	.0278	.0291	.0289	.2614	.2213	-.01	.00
100000	.0450	.0450	.0507	.0520	.2605	.2203	-.01	.02
125000	.0722	.0710	.0796	.0843	.2550	.2188	-.01	.02
144000	.1084	.1000	.1112	.1187	.2497	.2175	-.01	.02
160000	.1380	.1308	.1438	.1572	.2418	.2167	.01	.02
175000	.1754	.1648	.1786	.1985	.2325	.2158	.03	.02
188000	.2160	.2018	.2180	.2439	.2247	.2155	.04	.02
200000	.2604	.2422	.2580	.2930	.2037	.1926	.05	.02
226000	.3580	.3300	.3452	.3982	.1967	.1860	.09	.02
252000	.4740	.4306	.4458	.5181	.1800	.1814	.14	.04
275000	.5812	.5226	.5046	.6302	.1654	.1761	.20	.06
300000	.7204	.6408	.5745	.7781	.1533	.1697	.26	.08
325000	.8090	.7150	.5463	.8738	.1465	.1647	.32	.10
350000	.8990	.7870	.7240	.9698	.1373	.1519	.40	.12
375000	1.0750	.9130	.7585	1.1589	.1192	.1420	.58	.14
425000	1.4500	1.1400	1.0012	1.5540	.0748	.0911	.82	.18
437000	Maximum Load.							

COLUMN 8231

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total E. W.	Lateral Deformation Total N. S.	Lateral Deformation Unit E. W.	Lateral Deformation Unit N.S.	Deflection
57	.0000	.000000	.00000	.00000	.000000	.000000	.00
230	.0062	.000062	-.00005	.00007	-.000004	.000006	.00
442	.0160	.000160	-.00013	.00014	-.000011	.000011	.00
663	.0285	.000285	-.00009	.00015	-.000007	.000012	.01
883	.0482	.000482	-.00000	.00025	-.000000	.000020	.022
1105	.0768	.000768	.00055	.00040	.000045	.000032	.022
1275	.1096	.001096	.00108	.00053	.000088	.000043	.022
1415	.1425	.001425	.00187	.00061	.000152	.000050	.022
1550	.1793	.001793	.00280	.00070	.000227	.000057	.036
1660	.2199	.002199	.00358	.00073	.000290	.000059	.045
1770	.2634	.002634	.00568	.00302	.000470	.000246	.055
2000	.3579	.003579	.00638	.00368	.000520	.000300	.092
2230	.4671	.004671	.00805	.00414	.000654	.000336	.147
2430	.5597	.005597	.00951	.00467	.000770	.000380	.21
2650	.6635	.006635	.01072	.00531	.000870	.000430	.274
2870	.7360	.007360	.01140	.00581	.000926	.000472	.336
3090	.8450	.008450	.01232	.00709	.001000	.000576	.417
3310	1.1453	.011453	.01413	.00808	.001150	.000656	.596
3750	1.2863	.012863	.01857	.01317	.001510	.001060	.840


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Unit Load Lbs per sq. in.
.001


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Unit Load Lbs per sq. in.
.001
.002
.003
.004
.005
.006
.007
.008
.009
.010
.011
.012
.013
Unit Deformation inches per inch.
Column 8231
Length 9'-10½"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement
5/16 Hoops
Cement Universal
Mixture 1-3-6
Max load 437000
3750#□"

COLUMN 8232

Observed Data

Length 10 ft 0 in.
Gauge Length 100 in.
Circumference, 3 ft. 5 in.

Mixture 1-3-6.
Age when tested, 60 days.
Cement, Chicago AA.

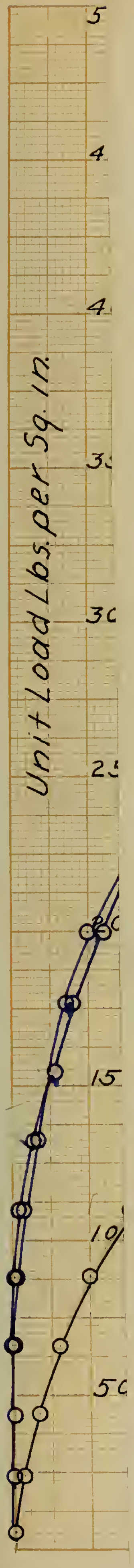
Reinforcement, 5/16 Bands.

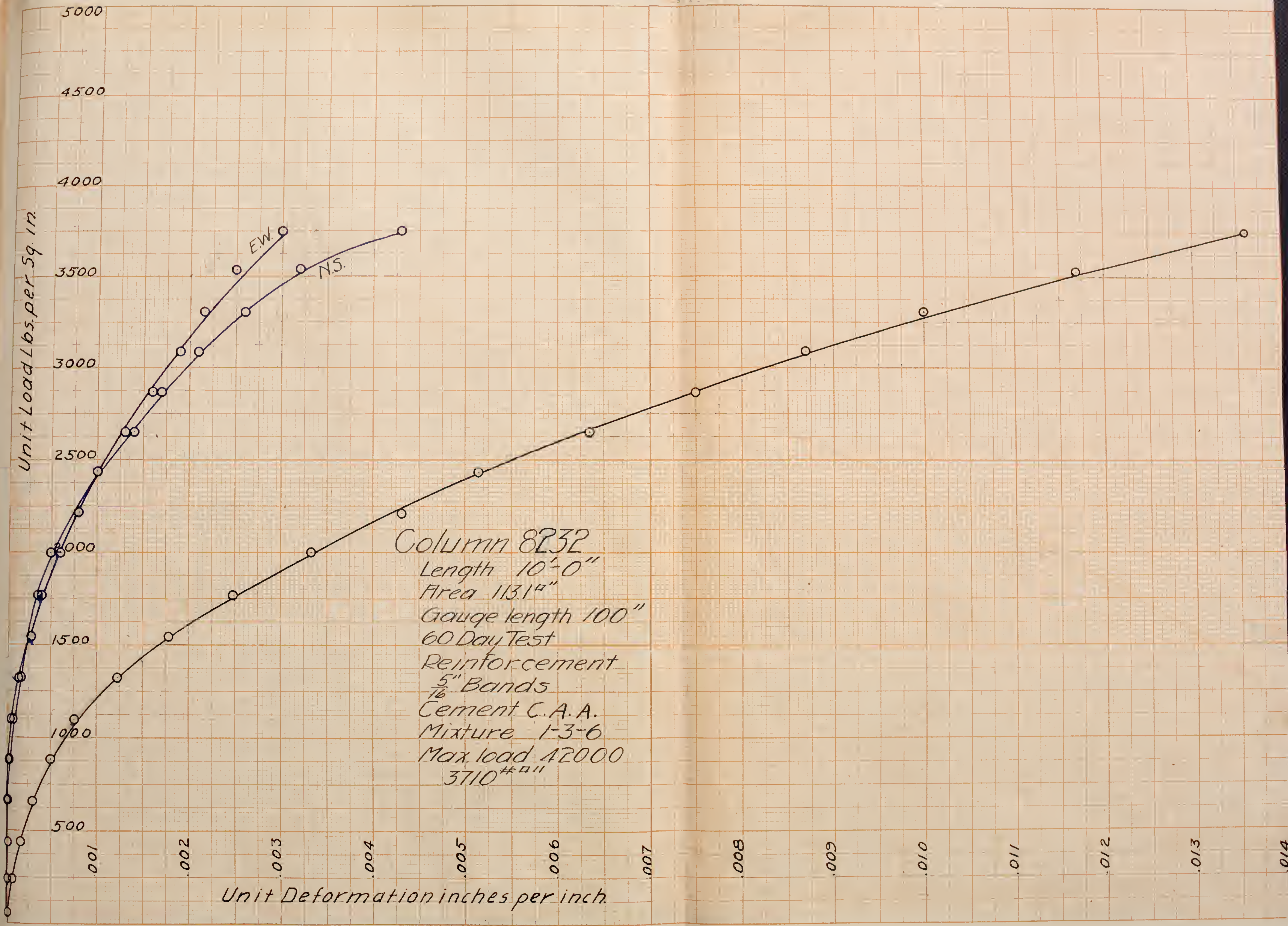
Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6000	.0000	.0000	.0000	.0000	.2663	.2810	.02	-.04
27000	.0068	.0051	.0062	.0050	.2723	.2806	.04	-.04
50000	.0166	.0132	.0158	.0150	.2719	.2801	.04	-.04
75000	.0308	.0254	.0298	.0292	.2715	.2791	.04	-.04
100000	.0564	.0410	.0430	.0558	.2649	.2766	.04	-.04
125000	.0910	.0606	.0662	.0918	.2610	.2712	.08	-.04
150000	.1416	.0950	.1060	.1445	.2470	.2619	.12	-.04
175000	.2040	.1412	.1540	.2062	.2340	.2470	.15	-.04
200000	.2820	.1998	.2158	.2832	.2200	.2312	.20	-.05
225000	.3778	.2704	.2882	.3760	.2007	.2068	.24	-.06
250000	.4908	.3504	.3718	.4830	.1705	.1834	.30	-.08
275000	.5976	.4288	.4520	.5002	.1385	.1515	.40	-.08
300000	.7234	.5232	.5480	.5270	.1085	.1087	.48	-.12
325000	.8582	.6236	.6440	.6660	.0750	.0693	.58	-.14
350000	1.0034	.7286	.7450	.8160	.0390	.0165	.72	-.18
375000	1.1796	.8340	.8580	1.0000	.2280	.1930	.90	-.22
400000	1.3750	.9306	.9740	1.1815	.1815	.1140	1.10	-.30
425000	1.6250	1.0538	1.1020	1.4800	.1260	.9872	1.50	-.44
420000	1.7850	1.0536	1.9600	1.9500			1.80	-.52

COLUMN 8232

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation E. W. Total	Lateral Deformation E. W. Unit	Lateral Deformation N. S. Total	Lateral Deformation N. S. Unit	Deflection
53	.0000	.000000	.00000	.000000	.00000	.000000	.045
238	.0065	.000065	-.00063	-.000051	.00004	.000003	.057
440	.0162	.000162	-.00056	-.000046	.00009	.000007	.057
662	.0303	.000303	-.00052	-.000042	.00019	.000015	.057
883	.0497	.000497	.00014	.000011	.00044	.000036	.057
1100	.0786	.000786	.00053	.000042	.00098	.000080	.09
1325	.1238	.001238	.00197	.000160	.00191	.000155	.13
1545	.1790	.001790	.00323	.000262	.00340	.000276	.155
1765	.2489	.002489	.00463	.000376	.00498	.000405	.207
2000	.3330	.003330	.00656	.000533	.00742	.000603	.25
2210	.4313	.004313	.00958	.000780	.00976	.000790	.312
2430	.5249	.005249	.01278	.001030	.01295	.001050	.408
2650	.6357	.006357	.01578	.001280	.01723	.001400	.495
2870	.7511	.007511	.01913	.001550	.02117	.001715	.596
3090	.8742	.008742	.02273	.001850	.02645	.002150	.742
3310	1.0188	.010188	.02673	.002170	.03211	.002610	.926
3530	1.1745	.011745	.03141	.002550	.03991	.003240	1.14
3750	1.3635	.013635	.03696	.003000	.05269	.004280	1.56
3710	1.8725	.018725					1.872


Unit Load Lbs. per Sq. In.
5
4
4
3
3
2
15
5



Column 8232
Length 10'-0"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement
$\frac{5}{16}$" Bands
Cement C.A.A.
Mixture 1-3-6
Max. load 42000
3710#□"

COLUMN 8221

Observed Data

Length 10 ft. 1½ in.
Gauge Length 100 in.
Circumference 3 ft. 4½ in.

Mixture 1-3-6.
Age when tested, 60 days.
Cement, Universal.

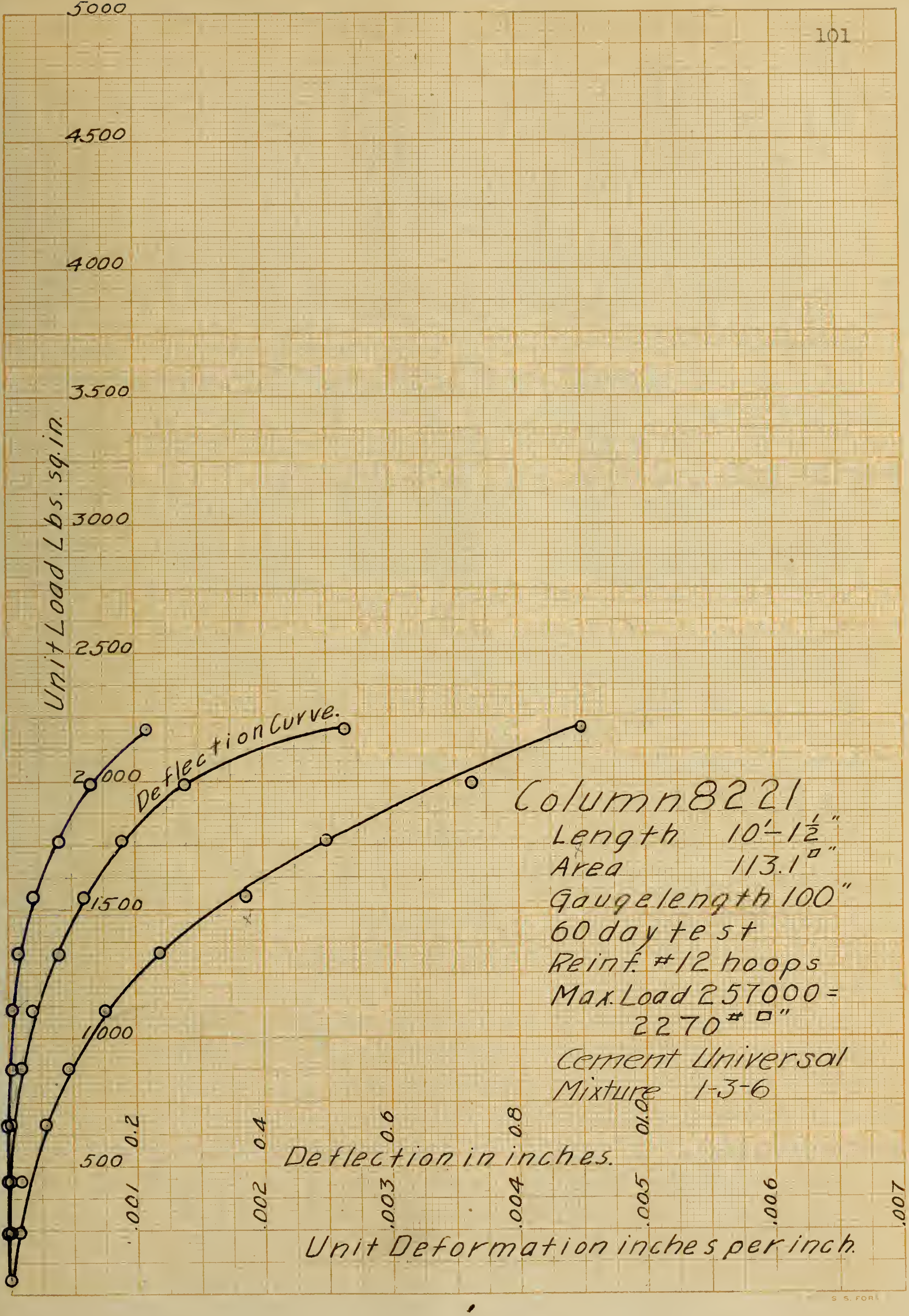
Reinforcement, No. 12 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Readings		Deflection	
	S.E.	N.W.	S.W.	N.E.	E.-W.	N. S.	N.E.	N.W.
6500	.0000	.0000	.0000	.0000	.2025	.2663	2.55	.40
27000	.0070	.0042	.0052	.0034	.2021	.2665	2.55	.40
50500	.0179	.0124	.0132	.0000	.2018	.2663	2.55	.40
75000	.0348	.0210	.0275	.0135	.2005	.2679	2.55	.40
100000	.0572	.0364	.0474	.0327	.1988	.2688	2.55	.42
125000	.0939	.0580	.0782	.0623	.1955	.2691	2.55	.44
150000	.1498	.0892	.1262	.1065	.1828	.2672	2.55	.48
175000	..2300	.1428	.1950	.1960	.1595	.2585	2.55	.52
200000	.3350	.1534	.2554	.2695	.1300	.2395	2.55	.58
225000	.4538	.1670	.3518	.3939	.0960	.2132	2.58	.68
250000	.4542	.2785	.4068	.5120	.0280	.1728	2.66	.92
257000	Maximum Load							

COLUMN 8221

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total	Lateral Deformation Unit	Deflection Inches
57	.0000	.000000	.000000	.000000	.00
238	.0056	.000056	.000030	.000002	.00
446	.0090	.000090	.000035	.000003	.00
663	.0279	.000279	.000180	.000015	.00
883	.0468	.000468	.000310	.000026	.02
1105	.0760	.000760	.000440	.000036	.04
1330	.1195	.001195	.001030	.000085	.08
1550	.1864	.001864	.002415	.000201	.12
1770	.2534	.002534	.004960	.000410	.18
1990	.3638	.003638	.007980	.000660	.28
2210	.4500	.004500	.013400	.001106	.53
2270	Maximum Load				


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Unit Load Lbs. sq. in.
Deflection Curve.
Column 8221
Length 10'-1½"
Area 113.1□"
Gauge length 100"
60 day test
Reinf. #12 hoops
Max. Load 257000 = 2270# □"
Cement Universal
Mixture 1-3-6
0.2
0.4
0.6
0.8
1.0
Deflection in inches.
.001
.002
.003
.004
.005
.006
.007
Unit Deformation inches per inch.

COLUMN 8222

Observed Data

Length 10 ft. 0 in.
Gauge Length 100 in.
Circumference 3 ft. 3½ in.

Mixture 1-3-6.
Age when tested, 60 days.
Cement, Chicago AA.

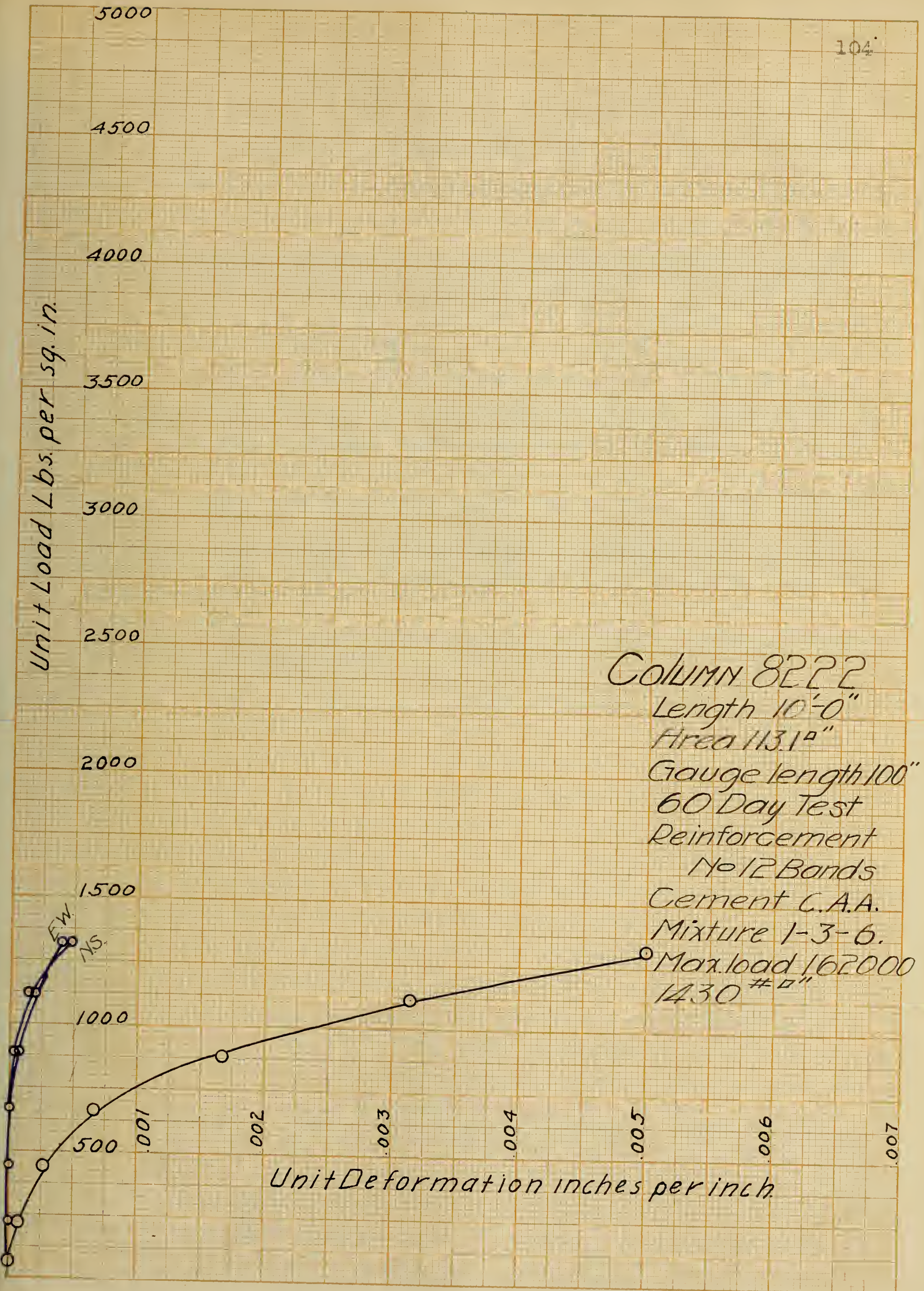
Reinforcement No. 12 Bands.

Load Pounds	Longitudinal Extensometer Readings				Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
7500	.0000	.0000	.0000	.0000	.2421	.2398	.00	.00
25000	.0080	.0076	.0082	.0020	.2421	.2396	.00	.00
50000	.0295	.0300	.0248	.0345	.2417	.2399	.00	.00
75000	.0764	.0800	.0580	.0642	.2411	.2415	.00	-.04
100000	.1938	.1820	.1425	.1350	.2341	.2371	-.04	-.12
125000	.3628	.3428	.2650	.2405	.2163	.2228	-.12	-.12
150000	.5884	.5684	.4180	.3748	.1896	.1850	-.14	-.22
162000	Maximum Load.							

COLUMN 8222

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation				Deflec - tion
			E. W.		N. S.		
	100 ins.	1 in.	Total	Unit	Total	Unit	
66.2	.0000	.000000	.00000	.000000	.00000	.000000	.00
222	.0081	.000081	.00000		.00002	.0000016	.00
442	.0271	.000271	.00004	.0000033	.00001	.0000008	.00
666	.0672	.000672	.00010	.0000082	.00017	.000014	.04
882	.1691	.001681	.00080	.0000658	.00027	.0000222	.126
1115	.3139	.003139	.00258	.0002121	.00170	.00014	.170
1322	.5032	.005032	.00525	.0004325	.00568	.000484	.272
1430							



Column 8222
Length 10'-0"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement
No 12 Bands
Cement C.A.A.
Mixture 1-3-6.
Max. load 162000
1430 #□"

COLUMN 8223

Observed Data

Length 9 ft. 11¼ in.
Gauge Length 100 in.
Circumference 3 ft. 4 in.

Mixture 1-2-4.
Age when tested,
Cement, Chicago AA.

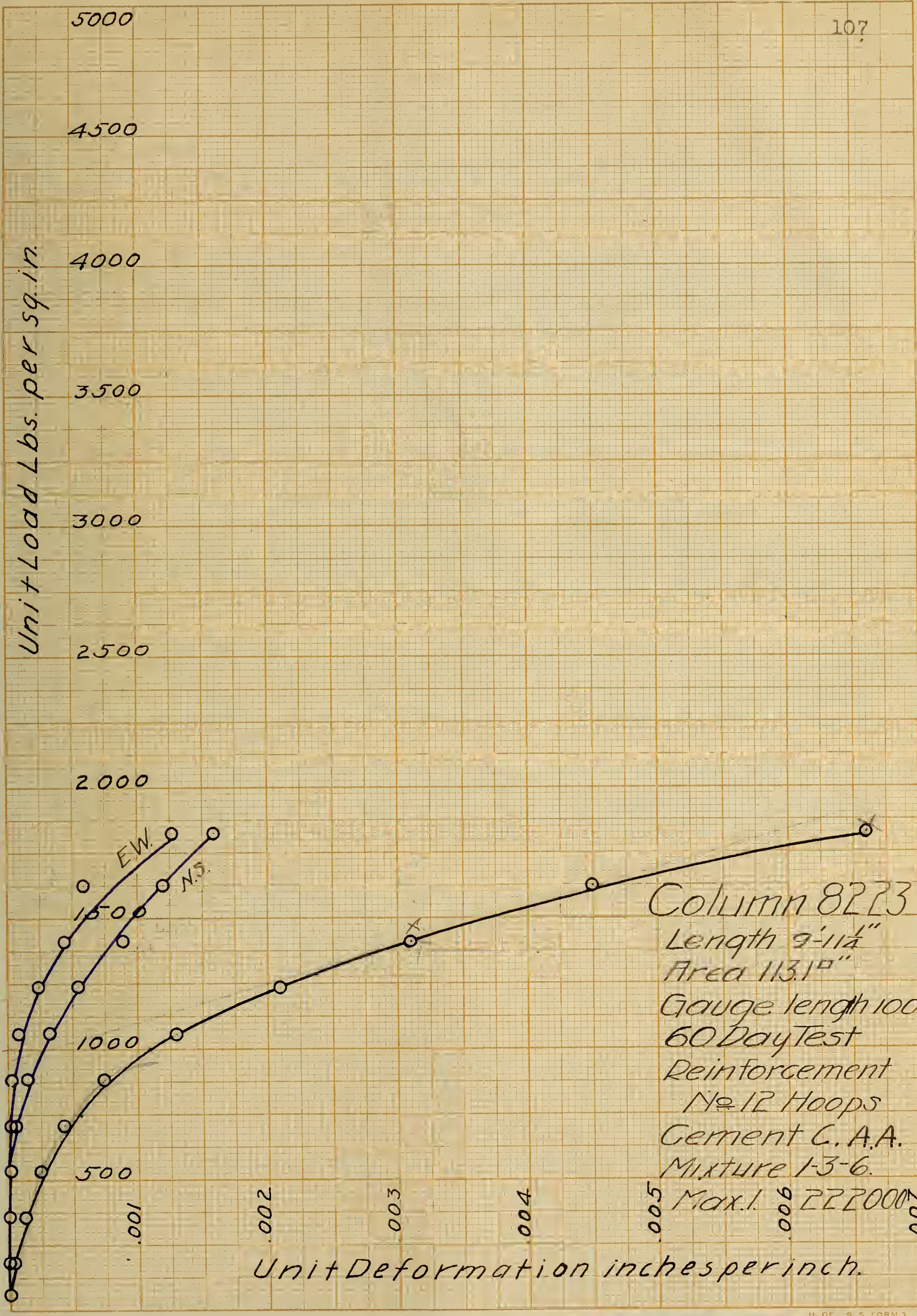
Reinforcement, No. 12 Hoops.

Load	Longitudinal				Lateral		Deflection	
Pounds	Extensometer Readings				Extensometer			
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
7000	.0000	.0000	.0000	.0000	.2580	.2724	.00	.00
20500	.0053	.0034	.0040	.0054	.2578	.2728	.00	.00
40000	.0090	.0104	.0144	.0142	.2576	.2712	.00	.00
60000	.0254	.0194	.0248	.0296	.2562	.2707	.00	.00
80000	.0420	.0335	.0442	.0515	.2551	.2655	.02	.02
100000	.0702	.0548	.0800	.0912	.2489	.2530	.03	.06
120000	.1225	.0982	.1408	.1586	.2288	.2333	.06	.10
140000	.1945	.1607	.2220	.2486	.2045	.2057	.10	.16
160000	.2945	.2453	.3294	.3705	.1759	.1646	.13	.25
184000	.4372	.3495	.4816	.5182	.1456	.1274	.20	.38
210000	.6505	.5055	.7046	.7738	.1048	.0798	.36	.62
220000	Maximum Load.							

COLUMN 8223

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per		Lateral Deformation				Deflection.
			E. W.		N. S.		
	100 ins.	1 in.	Total	Unit	Total	Unit	
61.6	.0000	.000000	.00000	.000000	.00000	.000000	.00
182	.0045	.000045	.00002	.000002	.00004	.000003	.00
353	.0120	.000120	.00004	.000003	.00012	.000010	.00
529	.0251	.000251	.00018	.000015	.00014	.000012	.00
706	.0428	.000428	.00029	.000024	.00069	.000057	.03
882	.0741	.000741	.00089	.000065	.00684	.00015	.067
1060	.1300	.001300	.00292	.000241	.00391	.000323	.118
1235	.2064	.002064	.00535	.000442	.00667	.000550	.19
1410	.3099	.003099	.00711	.000590	.01078	.00089	.285
1625	.4466	.004466	.01124	.000927	.01450	.00120	.434
1852	.6586	.006586	.01532	.00127	.01926	.00159	.720
1960	Maximum Load.						


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Unit Load Lbs. per sq. in.
.001
.002
.003
.004
.005
.006
.007
Unit Deformation inches per inch.
E.W.
N.S.
Column 8223
Length 9'-11¼"
Area 113.1□"
Gauge length 100"
60 Day Test
Reinforcement
№ 12 Hoops
Cement C. A. A.
Mixture 1-3-6.
Max. l. 222000

COLUMN 8211

Observed Data

Length 10 ft. 1 in.
Gauge Length, 100 in.
Circumference 3 ft. 3 in.

Mixture 1-3-6.
Age when tested, 60 days.
Cement, Universal.

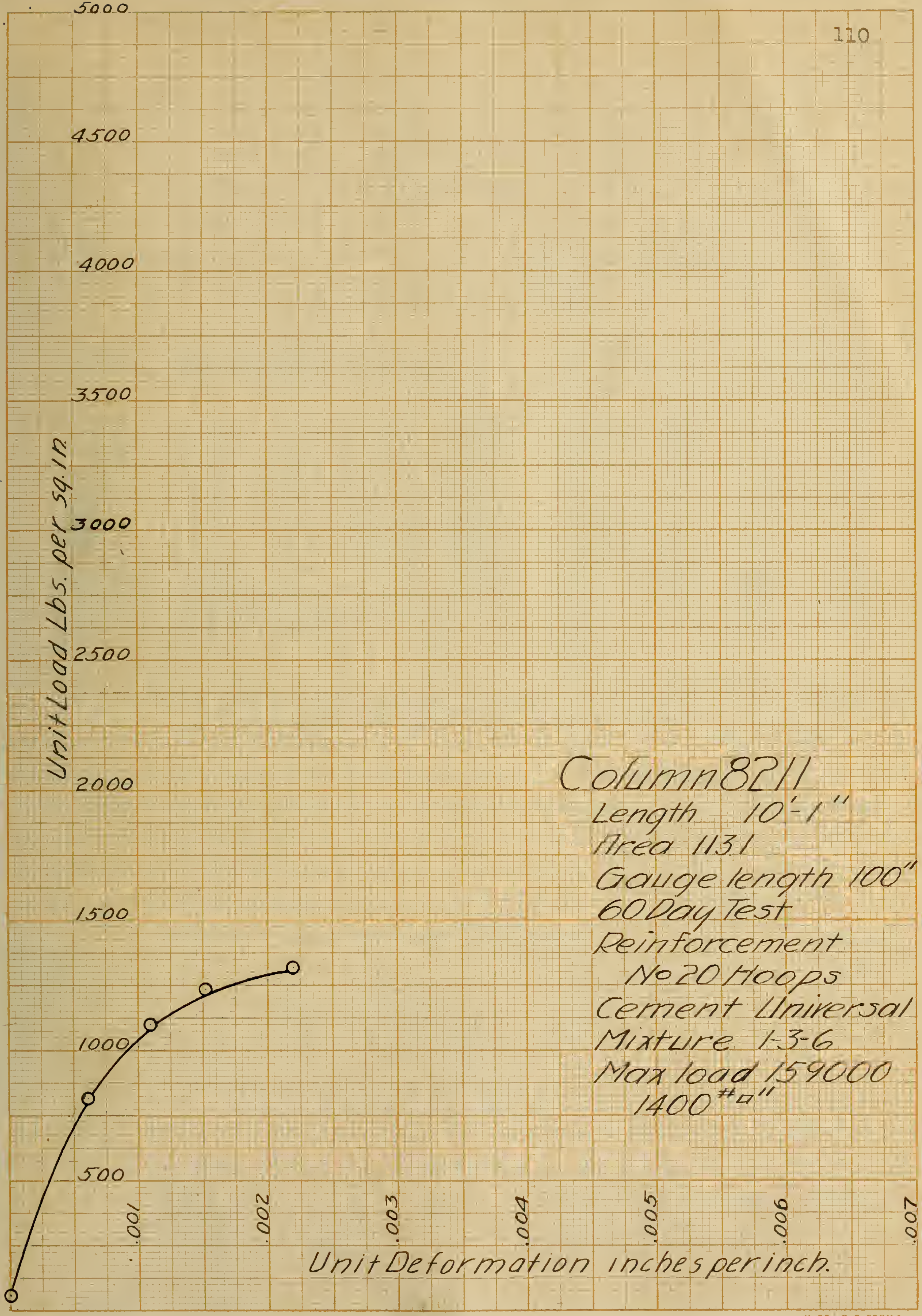
Reinforcement, No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Deflection.	
	N.W.	S.W.	S.E.	N.E.	N.E.	S.E.
6500	.0000	.0200	.0000	.0000	.10	.00
93000	.0512	.0770	.0675	.0659	.10	.04
125000	.0855	.1164	.1150	.1173	.10	.09
140000	.1238	.1644	.1690	.1719	.10	.12
155000	.1740	.2298	.2491	.2494	.10	.18
159000	Maximum Load.					

COLUMN 8211

Computed Data

Unit Load Lbs. per sq in.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Deflection Total
57.4	.0000	.000000	.00
819	.0604	.000604	.04
1101	.1088	.001088	.09
1232	.1523	.001523	.12
1320	.2206	.002206	.18
1400			



Column 8211
Length 10'-1"
Area 113.1
Gauge length 100"
60 Day Test
Reinforcement
No 20 Hoops
Cement Universal
Mixture 1-3-6
Max load 159000
1400#□"

COLUMN 8212

Observed Data

Length 10 ft. 0½ in.
Gauge Length 100 in.
Circumference 3 ft. 3¼ in.

Mixture 1-3-6.
Age when tested, 60 days.
Cement, Chicago AA.

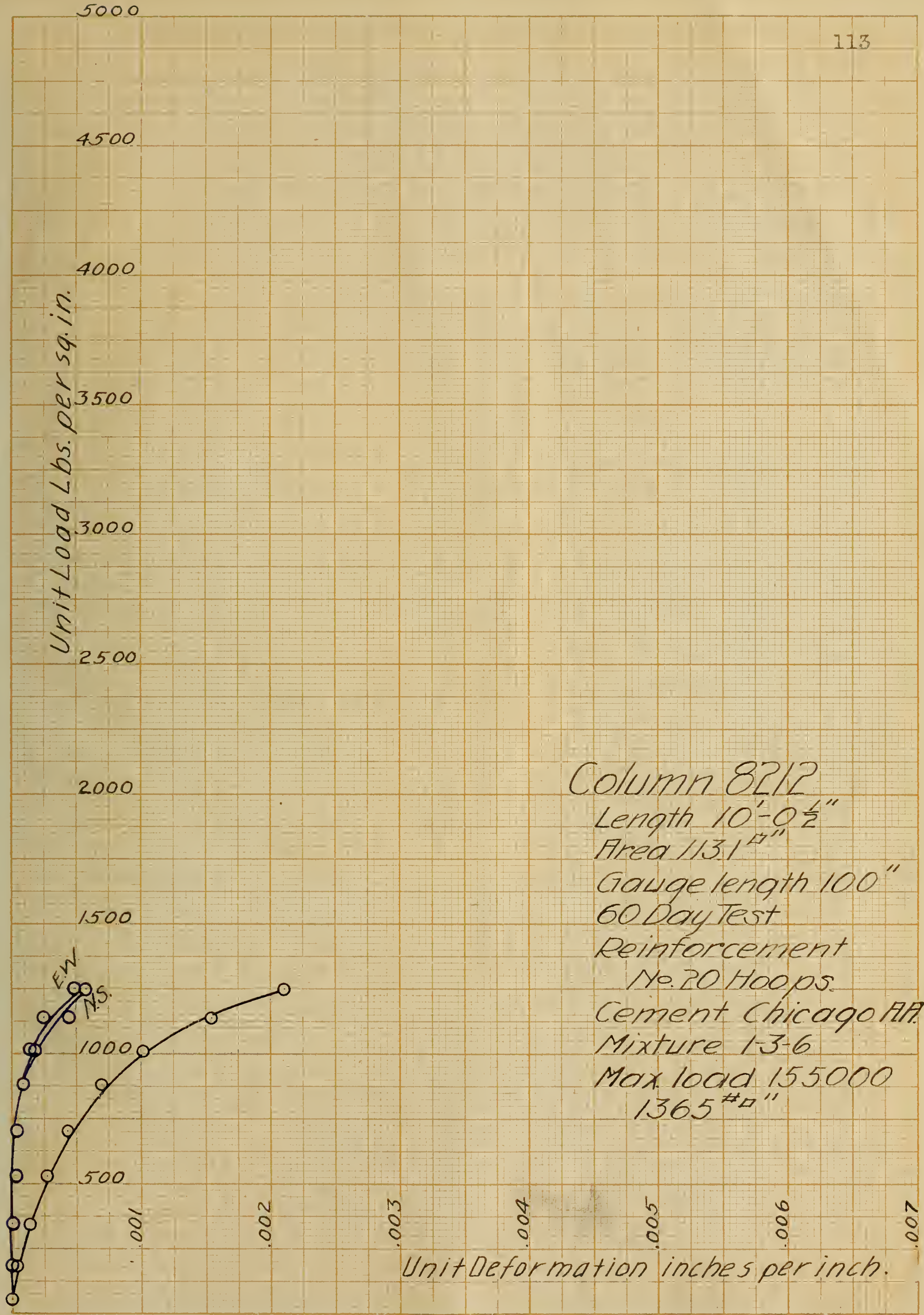
Reinforcement, No. 20 Hoops.

Load Pounds	Longitudinal Extensometer Readings				Lateral Extensometer		Deflection	
	N.W.	S.W.	S.E.	N.E.	E. W.	N. S.	N.E.	S.E.
6500	.0000	.0000	.0000	.0000	.2418	.2645	.00	.00
20500	.0061	.0043	.0038	.0050	.2417	.2634	.00	.00
39500	.0154	.0130	.0142	.0142	.2408	.2617	.00	.00
60000	.0280	.0252	.0250	.0282	.2390	.2594	.00	.00
80000	.0450	.0418	.0420	.0462	.2366	.2574	.00	.00
100000	.0724	.0673	.0658	.0740	.2319	.2535	.00	.00
115000	.1091	.1019	.0918	.1050	.2242	.2459	.00	.00
128000	.1680	.1540	.1372	.1630	.2116	.2232	-.02	-.04
142000	.2291	.2070	.1835	.2220	.1820	.1946	-.04	-.06
155000	Maximum Load.							

COLUMN 8212

Computed Data

Unit Load Lbs. per Sq. In.	Longitudinal Deformation per 100 ins.	Longitudinal Deformation per 1 in.	Lateral Deformation Total E. W.	Lateral Deformation Total N. S.	Lateral Deformation Unit E. W.	Lateral Deformation Unit N.S.	Deflection
57.4	.0000	.00000	.00000	.00000	.000000	.000000	.00
180	.0048	.000048	.00001	.00011	.000001	.000008	.00
348	.0142	.000142	.00010	.00028	.000008	.000023	.00
528	.0266	.000266	.00028	.00051	.000023	.000042	.00
705	.0438	.000438	.00052	.00071	.000043	.000059	.00
882	.0699	.000699	.00099	.00112	.000082	.000093	.00
1012	.1020	.001020	.00176	.00215	.000147	.000179	.00
1138	.1556	.001556	.00302	.00413	.000252	.000345	.045
1250	.2104	.002104	.00598	.00699	.000500	.000582	.07
1365	Maximum Load.						



Column 8212
Length 10'-0½"
Area 113.1□"
Gauge length 10.0"
60 Day Test
Reinforcement
No. 20 Hoops.
Cement Chicago AA.
Mixture 1-3-6
Max. load 155000
1365#□"